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ALGEBRA IN THE HIGH SCHOOL.

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Of all the high school course, perhaps no study is more vague in the mind of the student after he has completed it as to its purpose and results than is algebra. He may have worked faithfully, have acquired a fair degree of facility in performing the various mechanical operations, have become able to solve a fair number of problems, and he may even have a more or less definite understanding of some of the demonstrations of the principles involved; but it is probable that the general answer to the *why* of it all would be that by means of algebra certain problems (the most of them not practical) can be solved more easily than by arithmetic, or that a certain something classed as mental discipline has been secured. The work has been in the main purposeless and the pupil has done it merely because it has been assigned as a daily task, a part of a grind to be passed through in the hope that somehow, sometime in the future a value may appear.

This is wrong. Any work to be of educational value in any wide sense must be intelligent and must have a purpose in view. A pupil working an example in simplification of radicals with no understanding of why he is doing it except to get an answer is educationally on about the same plane as a dog which is being taught a new trick; to each the task is isolated and unrelated to anything else. One of the great reasons of the value of manual training is that back of every cut of the chisel or stroke of the hammer there is a definite purpose; the completed object with all its parts in their proper places is kept in mind. While the pupil realizes that he may never be called upon to do this work after he leaves school, and, in fact, he may be certain that his chosen occupation will be along quite different lines, he still is at no loss for a reason why he is doing what he is at present.

The same holds true in regard to commercial and other studies of a so-called practical nature; the student knows what they are for and he can tell what they will do for him if he masters them as he should.

While we may never be able to secure the clear definiteness of purpose in academic subjects which we can in manual training, yet there is certainly room for great improvement in this direction in our teaching. It may not always be necessary or even possible for the pupil to comprehend the broad general results, but any study worthy of a place in the high school course should have what may be called secondary purposes which will answer his question, "What is the use of this?" It may be of little use to explain to him that the great value of algebra lies in the mental ability which is developed in reasoning with sets of related facts, forming judgments and through mathematical operations arriving at definite results, but there are values which should appeal to the average pupil and which should be carefully kept before him from the time he begins until he completes the subject. As in the case of manual training, these may not be of any direct use to him after he leaves school, but they at least give a reason for the place of the study in the course he is required to take. A beginning of emphasis is made upon a few such values in some of the newer texts, but generally with such an indefinite and incomplete statement of just what is meant, and with so little illustrative matter that little headway is being made.

Translation in Algebra.

One value which should appeal to nearly all is the opportunity which algebra gives for translation, and this translation is necessary for the most successful work. At least one of the new books has recognized this by its introduction with its other exercises of the requirement to translate algebraic expressions into English. I find very little of this being done in actual practice. There appears to be a general misunderstanding of what is meant.

Algebra language is a universal language understood by students in other nations as well as our own, and a translation of an algebraic expression into English means just what a translation from Latin or German into English means, the statement of the meaning in clear idiomatic English. The pupil should be able to do this translating of the simpler expressions, and he should be brought clearly to understand that there is a definite

meaning back of even the most complicated algebraic expressions. A few examples will illustrate what I mean.

The expression $\frac{2a^2b-3b^3}{2b}-2b+ab$ translated might read about as follows: Three times *b* times *b* times *b* is to be taken from two times *a* times *a* times *b* and the result is to be divided by two times *b*; from this answer two times *b* is to be subtracted and *a* times *b* is to be added to this difference. A translation should also be made with values assigned to *a* and *b*. In beginning this work it is not best to allow even the use of the words "plus" and "minus"; like other algebraic symbols these should be translated into English. In algebra we are trained to think in symbols and letters rather than in long involved English expressions, and after a little practice we find it much easier to do this. Thus the product *xy* may, aside from the mere statement *x* times *y*, have many meanings; it may represent the cost of nineteen dozen eggs at twenty-seven cents a dozen, or it may be the distance an automobile will travel in nine hours at seventeen miles an hour. As long as I am thinking of eggs and their cost, *a* will represent to me the number of dozen, *b* the cost per dozen, and *ab* the cost of the whole. In a similar manner *abc* may mean to me a concrete problem having three factors. A clear understanding of this value of algebra and of the great advantage which it gives us in thinking from the very first day the subject is taken would help wonderfully in enabling pupils to work more intelligently and appreciatingly.

The simultaneous equations $6x+5y=28$ and $4x+y=14$ form a compound sentence in algebra, and the meaning is that: There are two such numbers that if six times the first be added to five times the second the result will be twenty-eight, and if four times the first be added to the second the result will be fourteen.

After some of this work has been done it is interesting to note the surprise of the pupils to find that a considerable amount of just this has been done by the author in the statement of problems and in translations such as that of the divisibility of certain binomials.

It should be noticed, too, that the first step in dealing with problems is the translation of English into algebra, a process corresponding to Latin or German composition. I remember with especial satisfaction the work of a class which was attacking problems producing simultaneous equations with the definite understanding that they were translating step by step not only

the English into algebra, but in case of error the algebra back into English to compare with the original.

The value of all this is evident. Not only does it give life and vitality to algebra by giving meaning to what has been too often meaningless, but it is excellent work in one line of English composition. In my judgment no study in the high school gives better opportunity for training in clear, accurate expression of definite thought, of saying just what is meant, no more, no less, than does algebra; translation can be tested, its truth determined by the pupil and the class and the speaker held responsible for his statements.

This work should be carried on from the very first. The idea so general among beginners that when the study of algebra is begun they have entered upon a new field of which they know almost nothing should be carefully guarded against; and while the meaning of some operations had better be taken upon faith, the faith should be fortified by an understanding of many other operations fully within the ability of the pupil through applications of what he already knows. Certainly he can understand that $3a$ means three times a; that $3a—2b$ means that two times b is to be subtracted from three times a; and that $\frac{3a-2b}{2a}$ means that two times b is to be subtracted from three times a and the result is to be divided by two times a; and finally that if in the last expression a represents seven and b five, the meaning is that two times five is to be subtracted from three times seven and the result divided by two times seven. This is something very different from merely checking up or proving by the substitution in the equation of the values of the unknown quantity, a good exercise, but one which is often deceptive as a test for the real understanding by the pupil of what he has done.

If I seem to be emphasizing too simple a matter it is because of the prevailing ignorance which I find existing among pupils in this and other respects which are fundamental to intelligent work. Even much of the blindness in regard to positive and negative quantities is needless and may be charged to lack of skill on the part of the teacher.

Algebra as a Simplifying Instrument.

Another value of algebra which even first year pupils can be made to appreciate is that of its use as a great simplifying mathematical instrument. I have often asked classes to find for me

the value of an expression such as $2\sqrt{5a^2b^3}$ if $a=7$ and $b=5$, or of $5\sqrt{150}-3\sqrt{24}$. The number of pupils who simplify before making the substitution or working out the necessary arithmetical operation is humiliatingly small. Comparatively few have ever grasped the idea that algebra has any real use in shortening the amount of work. I remember one instance in which a class had just simplified $\sqrt{50}$ into $5\sqrt{2}$. I asked if this meant that if I wanted to find the square root of 50 I might find the square root of 2 and multiply it by 5. All agreed that this was not the meaning, and that I could not get the square root of 50 in that way.

I am afraid that I am entirely safe in saying that if values are given to the letters in an example in division of polynomials and the exact value of the dividend divided by the divisor is called for, that nearly all teachers will find that the great majority of their pupils will make substitution without first dividing. This can have but one meaning: that this great value of algebra has entirely escaped comprehension. There is certainly nothing so abstruse in this that it cannot be understood from the time of the simplifying by the removal of parentheses so commonly given in the first pages, to the end of the course, and its thorough appreciation will help answer the question, "What is algebra good for?"

Algebra as an Instrument of Generalization.

Although considerable attention is given by texts and teachers to verification by substitution and to the few common generalizations such as the statements of divisibility of binomials and the common theorems of multiplication, extended tests show very little appreciation by pupils of the great value of algebra as a generalizing mathematical instrument. The fact that in such expressions as $(2x+y)y=2xy+y^2$ or $(15x^2-11x-14)\div(3x+2)=5x-7$, x may be any number and y any other number and that general statements may be made which are true for any values of x and y, has not at all appealed to the student; in other words, the work in algebra has been formal and meaningless instead of alive and purposeful in this respect.

Here again translation into English plays an important and necessary part. Mere substitution of values is not sufficient. The translation of the first of the above expressions would be about as follows: If two times any number be added to any other number, and the sum be multiplied by the second number, the result will be twice the product of the two numbers added

to the square of the second. The second expression means: If from fifteen times the square of any number eleven times the number and fourteen be subtracted, the result divided by two more than three times the number will always be seven less than five times the number. Of course, such translations should be accompanied by abundant verification with numbers.

This idea of generalization in connection with identical equations should be kept prominent throughout the study. The pupil should be made to thoroughly comprehend that there are ideas back of the different expressions and operations of algebra; that the answers to the exercises in least common multiple and greatest common divisor, the demonstrations of principles as well as the work in problems dealing with literal quantities have a definite meaning capable of expression in English which can be understood by people who have studied only arithmetic. It is easily possible to carry this beyond the ability of the pupil, though I believe that the average first year student may even be made to see the meaning of the known and unknown quantities in such equations as $ax+bx=c$, and that an understanding of what is meant by known and unknown numbers, and of the varying values of x may be reached much better through translation than by means of graphs.

Algebra should be taught as a tool for constant use in mathematical operations. The thorough appreciation of its great value as a simplifying and generalizing instrument, and of the advantage given by the ability to think in letters and symbols rather than in involved English expressions, together with a mastery of its universal language, will do much toward placing at least one academic study upon the same basis as manual training, commercial and other studies which are so successful largely because there is always in view a definite purpose, an end to be reached. At the same time every formal value usually assigned to algebra will be incidentally reached just as the pedagogical thought of the teacher of manual training is worked out while the boy knows or thinks of nothing beyond the chair or the table which he clearly images as he works and which gives him the purpose which lies back of every stroke of the chisel and saw.

The obscurity, vagueness and mystery which now, as shown by many tests, exist in the minds of the majority of even the best of students can be largely avoided, and algebra can be made, instead of one of the most indefinite and uninspiring of studies, one which is alive with meaning and purpose.

A STUDY IN EFFICIENCY.

BY ERNEST W. PONZER,
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One of the most important and far-reaching questions in the realm of engineering practice is that of efficiency. All machines are designed to have their efficiencies as high as possible, the goal to be striven for being that synonym for perpetual motion, an efficiency of *one*. That this cannot be attained is well known; nevertheless every machine is designed to work as near to this ideal efficiency as possible.

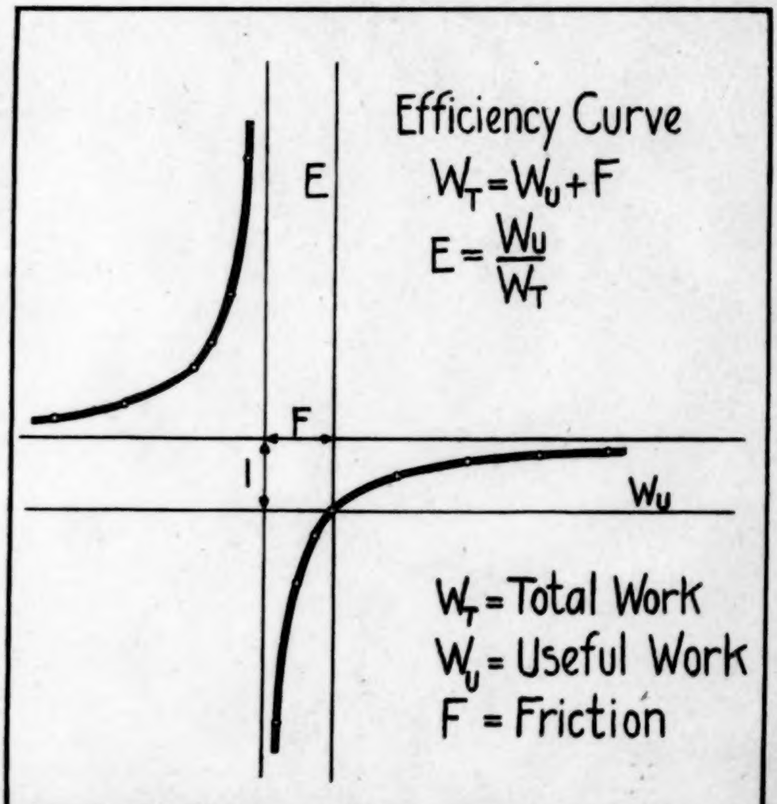
Two general principles applicable to a single machine or group of machines are expressed in the following equations:

$$W_T = W_U + F.$$

$$E = \frac{W_U}{W_T}$$

If W_T be eliminated the relation between W_U and E becomes

$$W_U = EW_U + EF,$$



an hyperbola when plotted as shown in the accompanying figure, in which the symbols used are also explained. Let us make a study of this relation and apply the bit of philosophy it contains to our class room practice and affairs of everyday life.

It will be seen that the factor F, constant, or nearly so, for a machine working under the same conditions, should be made as small as possible in order to obtain a high efficiency. That this is recognized in the engineering field is evidenced by the fact that in modern practice manufacturing plants are designed with a minimum of line shafting and accompanying belts, all tending to increase this friction factor. Instead there are installed electric motors with efficiencies approximating the *one* striven for, separately connected with the machines, or units of machines.

Let us make the application to the class room. Certainly any influence serving as a drag or constant source of friction, which must be overcome before useful work can be done, should be eliminated. Every student has a right to work in well-lighted and ventilated rooms; to find in them ample equipment and an optimistic instructor; and, on his part, to present himself with a clear head and a proper appreciation of the value of what he is doing. This friction factor in engineering lines has been known to become so excessive that the machine has been put entirely out of commission; in the class room a lack of any or all of the above, coupled with a violent attack of spring fever, has broken up many a class. It is absolutely essential that this friction factor be reduced to a minimum.

Let us further investigate how the efficiency increases with the useful work as an output. It will be seen from the figure, since we are interested mainly in that portion of the curve to the right of the E axis, that the efficiency of a machine or plant increases with the output of useful work. To obtain the maximum efficiency it is essential that a machine be worked to its limit (we have lately learned to use high speed tool steel); likewise that a plant have all its machines doing efficient work. When the whistle blows and the wheels begin to turn, the efficient superintendent wants to have all his men at work, each getting results, and the man who is late should be "docked," not only because he himself is not producing, but also because he is by that action decreasing the efficiency of the whole plant. Likewise when the whistle blows on the other end it is highly desirable

that all stop work simultaneously, thus eliminating the friction factor.

How clearly all this is applicable to the class room. Work should begin with the tap of the bell and close on the same. A few tardy students may utterly destroy for the time being the efficiency of the whole class; on the other hand, an instructor tardy in closing his work with the tap of the bell is likewise developing at that time a low efficiency because the useful work is tending toward a minimum. Every student should participate in a discussion, or be listening to a demonstration by either the student or instructor. A full and high efficiency is not obtained short of this team work, and it is up to the instructor to insist that all should work efficiently throughout the hour. The desirability of well-regulated study periods, such that the student is doing real work while busy, and vacation periods in which the student should loaf with equal efficiency, is also plainly pointed out here. Whatever is worth doing is worth doing well and in the shortest time consistent with good work. In the engineering world the man who has grasped the fundamental principles of efficient work, and has the ability to keep the efficiency of a body of workmen high, is called a good manager, and is well paid because he is a rare man. In the class room that instructor is the most efficient who also recognizes these same principles and applies them intelligently, thus creating a maximum of useful work, at the same time attaining a high efficiency. And the students all this time form a unit of thinking machines of high grade.

The rains of last November in Jamaica were among the most remarkable ever recorded in any part of the world. Official returns at hand show that the maximum rainfall occurred at mountain stations in the eastern part of the island, viz., 135 inches in 8 days at Silver Hill, with a maximum daily fall of 30.50 inches on the 6th, and 120.87 inches in 16 days at Farm Hill. These figures are comparable with the famous downpours at Cherrapunji, India, where 41 inches have been measured in a day and 114 inches in five days. The Jamaica rains caused disastrous floods and landslides, attended by loss of life and property.

Word comes from Johannesburg, South Africa, that a large body of iron ore has been discovered in Natal, only thirty miles from the railroad and within a radius of seventy-five miles from the coast. Coking coal has also been located in Natal; limestone has also been found in large quantities near the ore beds. The river Tegela, which is suitable for the development of hydro-electric power, has its course through the iron ore property. With everything at hand for the manufacture of iron it is altogether likely that these properties will soon be turned to commercial account.

TRISECTING ANY ANGLE BY MEANS OF A HYPERBOLA.[1]

By W. A. Knight,
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Let ABC be any angle. From the vertex B, with any convenient radius, strike an arc cutting the sides of the angle at A and C. Join C and A and prolong to x'. By any convenient method divide AC into three parts, one point of division falling at D, and from A set off AF=AD=⅓AC. With D as a center and F and C as foci construct an hyperbola passing through G. The point of intersection x of the arc and hyperbola E will be one third the length of arc from C. Hence a line through the vertex and the point E will give an angle EBC=⅓ABC. The other third can be obtained by bisecting ABE, or cutting the arc AE with EC as a radius and A or E as center. This construction will hold for any angle, either greater or less than 180°. If the angle be greater than 180°, the vertex of the triangle formed by joining A and C, *i. e.*, the vertex B of the triangle ABC, will lie between the chord and the arc.

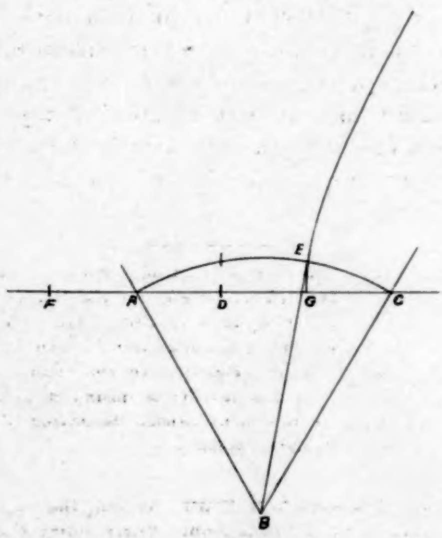

Fig 1

Proof I.

On a line AC strike any number of circular arcs terminating in A and C. The locus of a point so moving as to cut off a

[1]Since writing the above, I have learned through Professor J. W. A. Young of the University of Chicago that this same solution is given in a work published in 1891.

length from C equal to one third of each of the arcs will so move that any point P on the locus will be twice as far from C as from the line OY, the perpendicular bisector of the segment AC. Therefore, if P be any point on the locus, CP=2MP. This, by definition, is an hyperbola having C as focus, OY as directrix and eccentricity equal to two.

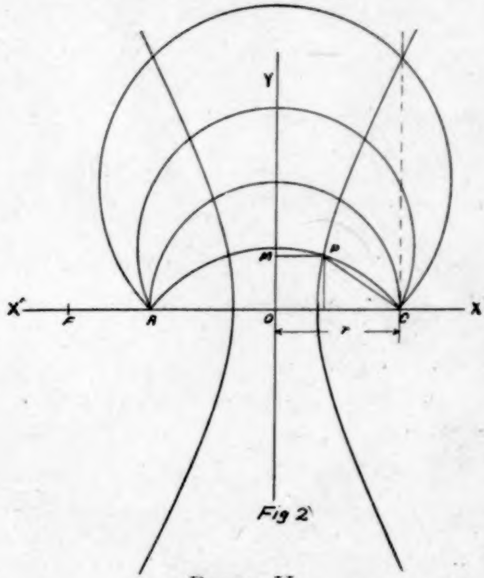

Fig 2

PROOF II.

Take the origin at O and let $OC=r$; we then have, since $CP=2x$, $(r-x)^2=4x^2-y^2$. Expanding the left-hand member and solving for y gives (1) $y^2=3x^2+2rx-r^2$ as the equation of the curve. This is the equation of an hyperbola with its center on the X axis at a distance $\frac{1}{3}r$ to the left of O.

Since the point P was taken on any circular arc that can be described upon a line AB, it follows that the resulting curve will trisect all circular arcs that it is possible to construct upon the given line. It therefore trisects the original arc.

Let $y=0$; then $3x^2+2rx-r^2=0$; from which

$$(3x-r)\ (x+r) = 0,$$

$$x=\tfrac{1}{3}r \text{ or } -r.$$

Hence the curve cuts the X axis at a distance $\frac{1}{3}r$ to the right of O and at a distance r to the left of O. It may be observed that the left-hand curve passes through the point A, which may be regarded as the terminator of all arcs that can be described upon AC.

WHAT DISTINGUISHES TRIGONOMETRY?

By A. Latham Baker, Ph.D.,
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"Trigonometry is usually regarded and taught as a separate subject, but when we come to seek its peculiar characteristics, we fail to find a clear-cut central idea which would serve to give the subject its own individuality. Arithmetic has to do with the number concept, algebra with the generalized number concept and the equation, and geometry with the space concept and its problems. These central thoughts are distinct and fundamental * * * each of the subjects has its own very marked individuality. What is the corresponding distinctive characteristic of trigonometry?" (*Young*: *The Teaching of Mathematics*).

The author answers the question negatively and concludes that trigonometry has nothing distinctive. Of course, definitions are arbitrary and any writer is at liberty to make any definition he pleases as to the boundaries of his subject, so long as he is consistent and does not violate common usage too violently. But definitions are for the purpose of circumscribing, limiting, distinguishing and separating one thing from another. Economy of terms and clearness require that the lines of demarkation between the different parts defined should conform as closely as possible with the natural lines of cleavage imposed by the nature of the thing defined.

It would be foolish and meaningless to define arithmetic as that branch of mathematics studied in the little red schoolhouse and algebra as the branch studied in college. It is almost equally meaningless to define algebra as generalized arithmetic. That the world has long disregarded the natural line of cleavage between the two subjects does not obliterate the line nor lessen the desirability of using this line of cleavage as the separating line between the definitions of the two branches. The literal equation was for a long time the earmark of algebra, but the mathematical world has been gradually drifting into the recognition of the literal equation in arithmetic, and into the appreciation of the real gap between the subjects—the gap between positive number and negative number.

Arithmetic in its general treatment has dealt historically only with positive numbers, leaving negative numbers, and quite unnecessarily, the literal equation for algebra. Here is the natural

line of cleavage, and if definitions are to have any natural lines of distinction, here is the place where that line should come; arithmetic, the science of positive numbers; algebra, the science of negative numbers; irrespective of literal symbolism.

So when we come to elementary geometry, the subject is limited by the tools allowed, straight-edge and compass. The ancients imposed this limitation because they had no other simple instruments with which to draw lines; and moderns have followed the same limitation for the same reason. Now, elementary geometry deals, among other things, with the ratios of the sides of triangles, and might easily have used the six trigonometrical ratios. But right here we are met with the limitation imposed by the tools used. Logically our six ratios can only be used in application to the angles which can be measured in elementary geometry, the Euclidean angles, 90°, 60°, 36° and their multiples, dichotomic submultiples and combinations.

But the introduction of a new tool, the scale, enables us to apply the six ratios to any angles, and introduces the general measurement of angles, trigonometry (goniometry). This is what distinguishes trigonometry from geometry and gives it its individuality—the graduated scale. Without the scale we are confined to the relatively few angles found in elementary geometry; with the scale we find ourselves in the general field of goniometry.

An added tool opens new doors. As soon as you allow other tools than the historic straight-edge and compass, you open the door to other and individual branches. The graduated scale opens the door to trigonometry; a tool for drawing conic sections would logically open the door to that branch; the integraph opens the door for the famous problem of the rectification of the circumference. Confine yourself to straight-edge and compass and you cannot measure the general angle; confine yourself to discrete number and you cannot square the circle. But add the graduated scale and you open the door to trigonometry; add the integraph and the circle becomes rectifiable.

Hence, in conclusion, the individuality of trigonometry is marked by the acquisition of the scale and the consequent ability to measure all angles.

A convenient and rapid way of repairing holes in wave-troughs and aquaria is to run a little melted paraffine into the cracks and holes between the glass and frame work by means of a hot iron.

A CORRELATION OF MATHEMATICS AND PHYSICS.

BY LINDLEY PYLE,
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Many teachers of mathematics are on the alert to add interest to the elucidation of the equations and curves of the analytical geometry by reference to familiar physical problems. Teachers of physics find the judicious use of the graph of inestimable value in the discussion of related physical quantities. The following simple case of the correlation of mathematics and physics may prove of interest. It is presented because of the frequency with which there occurs in the physical investigation of two quantities the relation indicated by the hyperbola,

$$y = -C_1\frac{y}{x} + C_2 \qquad (1)$$

Connect a nonpolarizable cell, say a Daniell type, of electromotive force, E, to a variable resistance, R[1]. Vary R and take corresponding readings, V, of the potential difference at the cell terminals by means of an attached voltmeter. See Fig. 1. Plot the related pairs of values of V and R. Fig. 2. The curve rises from the origin with V apparently approaching a limiting value. Since V is not proportional to R, it may be profitable to investigate how V depends upon this variable ratio $\frac{V}{R}$. Plotting V and $\frac{V}{R}$ one obtains a straight line of negative slope. See Fig. 3. The equation of any straight line is $y=mx+c$.

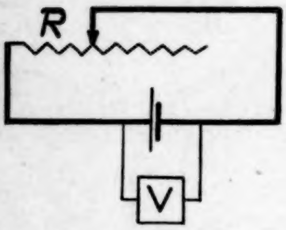


Fig. 1

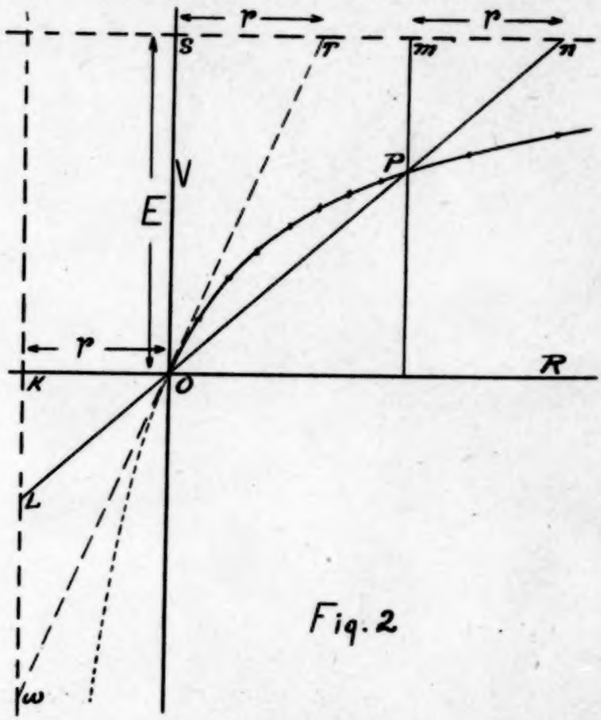
The equation of this particular line is $V=-m\frac{V}{R}+c$ **where** $-m$ represents the negative slope. Note that m is constant and has the dimensions of a resistance. It must be a constant resistance and internal to the cell. Call it r. c is the V intercept. It is the value of V when $\frac{V}{R}$ is zero, that is when R is infinite. It is therefore the terminal potential difference of the cell on open circuit. Call it E. Then

[1]Neither R nor the internal resistance of the cell should exceed one hundredth of the resistance of the voltmeter.

$$V = -r\,\frac{V}{R} + E \qquad (2)$$

The ratio $\frac{V}{R}$ is given a symbol, I, and a name, "Current." So that equation (2) can be written $V = -rI + E$
or $E = V + Ir$

(Note that equation (2) is of the same form as equation (1).)



Fiq. 2

$V = E$ for $R = \infty$. Whence $V = E$ is evidently the equation of one of the asymptotes of the curve of Fig. 2. Further, were it physically possible to make R negative, V would be negative (See dotted part of curve in Fig. 2). For $R = -r$, V would become negative and infinite, since the resistance of the entire circuit would then be zero. Evidently $R = -r$ is the equation of the other asymptote. Draw in the asymptotes such that $OK = r$ and $OS = E$. The values of r and E are respectively the slope and V intercept of the straight line in Fig. 3.

The value of r may be found as follows. In Fig. 2 choose any point P on the curve. Draw the straight line OP and produce to the asymptotic line at n. Produce the ordinate through P to m. By similar triangles

$$\frac{mn}{R}=\frac{E-V}{V} \quad \text{By equation (2),} \quad \frac{r}{R}=\frac{E-V}{V}$$

$$\therefore mn=r$$

This construction is independent of the location of P. It holds even if r be variable, in which case the curve will depart from an hyperbola. The slope of any such secant line through O represents the value of the current delivered by the cell for that value of R represented by the abscissa of P. Sn represents the total resistance of the circuit. KL ($=m$P) represents the internal drop of potential over the resistance of the cell.

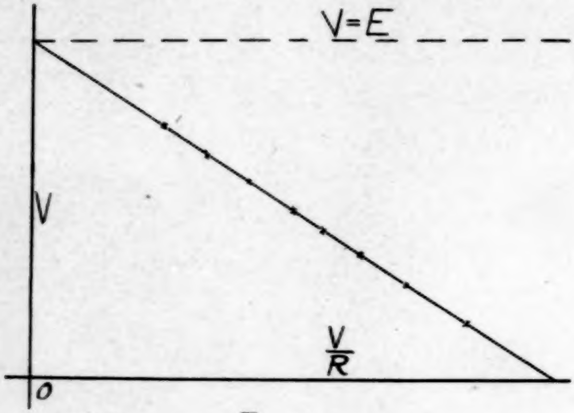


Fig. 3

Let P approach O. When P coincides with O the line OP is tangent to the curve at O. This is the line OT. The tangent may be constructed by laying off ST $= mn$ (assuming r constant). The slope of this tangent represents the current delivered by the cell on a short circuit. The $\frac{V}{R}$ intercept in Fig. 3 also represents the current on a short circuit. KL has now increased to KW ($=$ E).

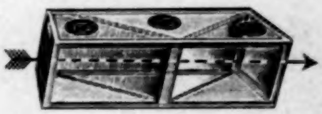
Many other interesting properties of the curve might be pointed out. It is perhaps unnecessary to remark that such methods of discussion not only vitalize mathematics but clarify physics.

What is said to be the first long-distance, high-tension submarine cable ever laid, has recently been put in Oneida Lake, New York State, connecting Frenchman's Island with the mainland. The cable is to conduct a current at 6,600 volts pressure to the island, where it will be stopped down to 110 volts and used for lighting the pavilion and operating the various amusement apparatus on the island.

A NEW STRAIGHT-VISION PRISM FOR THE PROJECTION OF SPECTRA.

By Joh. Koenigsberger,
Professor at Freiburg, i. B.

The straight-vision fluid prism here described has the same power of dispersion, and therefore a spectrum of the same size, as the best prisms according to Wernicke. On the other hand, its construction is much simpler and the cost of manufacture for the same size and capacity only about half and less of that for Wernicke prisms. An acid-proof, nearly rectangular fluid-trough, as the illustration shows, puttied at 600° C., is divided into three prisms, the two outer ones of which are filled with a fluid of slight dispersion, the inner one



with a fluid of high dispersion and similar index of refraction. The fluids remain in the puttied prisms, do not change, and need not be removed after using them. Only at temperatures below 0° do they freeze, and then it will be sufficient to put the prisms for ten minutes in a warm room to render them ready for use.

Up to now, straight-vision prisms have been furnished in the following four constructions:

1. Combination or crown and flintglass prisms according to Amici-Jansen and Rutherford prisms (dispersion 3°—3, 5°). These prisms are very good for correct measuring, their dispersion being much less dependent on temperature. For projection, however, their dispersion is smaller than that of fluid prisms, apart from the fact that the latter are much cheaper, particularly if large sizes are required.

2. Fluid prisms giving violet up to 380 m.m. Dispersion C—F— about 2, 30°—4°.

3. Fluid prisms with a filling allowing only the colors up to blue. Dispersion C — F about 3°—5°.

4. Combination of straight-vision prisms by connection.

The new prism belongs to category 2, has, at 15° C., a dispersion C—F— of about 4°, and gives the spectrum up to 400 m.m. If a very strong dispersion, about twice that of Wernicke prisms, is desired, two prisms are firmly united into one system. This is to be preferred to the manufacture of five-part prisms or to the reflection of the back side of one prism.

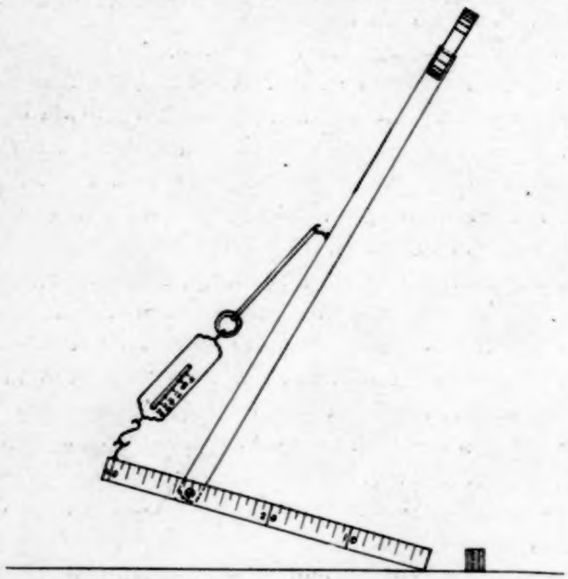
The above prisms are made by the optical works of F. Hellige & Co., Freiburg i. B., and can be had through any dealer of scientific instruments.

A LEVER OF THE SECOND CLASS.

By G. J. Koons,
High School, Murphysboro, Ill.

There is a difference of opinion as to what class of lever is employed in raising the body upon the toes. Some call it a lever of the first class, while others say that it is a lever of the second class.

A lever is usually defined as a bar capable of rotating about a fixed point in it. The fixed point is called the fulcrum. A lever of the first class is one in which the fulcrum is between points of application of the power and weight. A lever of the second class is one in which the weight is applied between the fulcrum and the power. In both classes, when equilibrium is established the moment tending to produce rotation in one direc-



tion is equal to the moment tending to produce rotation in the opposite direction. Theoretically, any second-class lever may become a first-class lever by considering the point of application of the weight as the fulcrum. Similarly, any first-class lever may become a second-class lever by considering the pressure at the fulcrum as the weight. From these facts it seems that determining whether or not raising the body upon the toes is a lever of the first or second class is simply a matter of deciding

on the location of the fixed point around which there is a tendency to rotate.

To lift the body upon the toes it is necessary to incline the body forward until the line of direction passes through the base formed by the contact of the toes and the floor. The muscles of the calf of the leg then lift the body. The muscles being attached to the bone above pull down with a force equal to that with which it lifts. Thus the downward pressure at the ankle is equal to the weight of the body plus the downward pull of the muscle. In the case of a person weighing 150 lbs. the pressure of the toes of each foot on the floor would be 75 lbs. The muscles of the calf of the leg would then exert an upward pull of 150 lbs. The downward pull of the muscles added to half the weight of the body makes a weight of 225 lbs. supported at each ankle.

An illustration of these conclusions is shown in the figure. The piece of apparatus is easily constructed and confirms the statements already made. A heavy mass is fastened at the top of the upright; the whole apparatus is inclined until it stands in equilibrium.

It seems that raising the body upon the toes satisfies the equation for the lever of the second class. As the fixed point around which the tendency to rotate is the point of contact with the floor, according to the definition of the lever of the second class, the conclusion naturally follows that it is a lever of the second class.

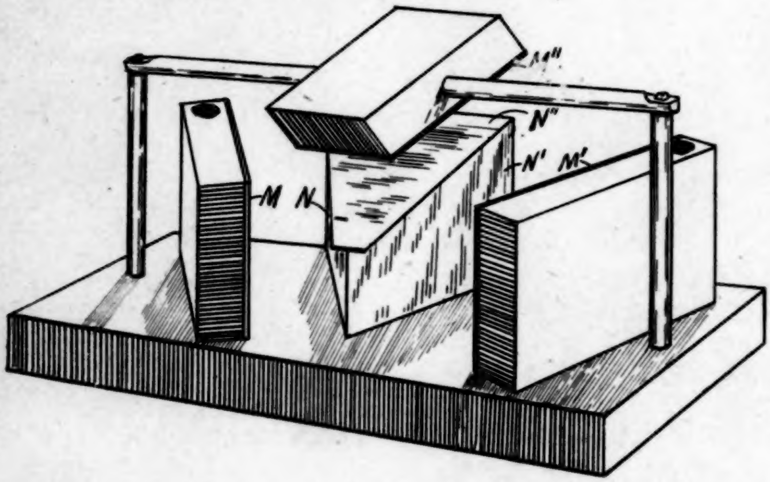
Cast iron, steel, and wrought iron can be readily distinguished from one another by means of nitric acid. Take a piece of the metal to be tested and file a small section of the surface so as to give a bright spot. Apply to this spot a drop of nitric acid and after a few minutes wipe it off and rinse with water. If the metal is wrought iron the acid will leave a whitish-gray mark, if steel a brownish-black one, while if it is cast iron it will be deep black. The test is based on the fact that the three metals each have a different carbon content and the effect of the acid is to expose the carbon. The test is quite valuable for determining the relative proportion of the different metals when two or more of them are welded together.

Considerable attention has been directed of late to the effect of sunlight on the transmission of Hertzian waves. A writer in *Electrotechnische Zeitschrift*, in commenting on this subject, points out that the stronger the sunshine the less the conductivity of ether to the Hertzian waves, so that it is incorrect to speak of a wireless telegraph station as having any definite range; for one which has a large radius of communication in northern latitudes would have a much smaller radius in the tropics. This would be particularly noticeable on vessels sailing north and south, and he suggests that it would be desirable to prepare a "radio-topographical" map, giving the relative conductivity of the ether at different latitudes.

A METHOD FOR SUPERPOSING COLORS.

By F. R. Garton,
State Normal College, Ypsilanti, Mich.

In the June number of School Science and Mathematics the author described a simple device for the blending of colors upon a screen; for example, any two complementary colors. A modification of this apparatus suffices for the superposing of three colors, as the primary colors (red, green, and violet) of the Young-Helmholtz theory. The necessary changes in the apparatus are apparent from the figure.



The wedge-shaped block at the center of the apparatus, which in the former arrangement was provided with two mirrors, is, in this case, cut at the top at an angle of 45° and is here faced with the mirror N″. When placed before the objective of a lantern, this mirror reflects the incident light in an upward direction. This light is caught by the mirror M″ and thrown upon the screen.

If, now, a lantern slide is prepared with three transparent openings at the corners of an isosceles triangle about 1¼ inches on a side, and these openings covered with films of the colors to be superposed, each of the three central mirrors may be made to reflect a certain color. Each reflected color is turned by a second mirror toward the screen. By adjusting the movable mirrors, the three colored spots may be made to overlap to any extent. The same apparatus obviously suffices for the blending of two colors in the manner described in the previous article.

PHYSICS AS A FACTOR IN FORMING CHARACTER.

By Charles M. Brunson,
Central High School, Toledo, Ohio.

What a man is, is his character; and what he is, is what his own or his ancestor's experiences have made him. Character is not a spontaneous generation. It is a growth from transmitted life. It is a slow, steady development and contains an admixture of all three elements—mental, moral, and physical. These elements are interdependent and cannot, therefore, be separated in their development. What affects the one also affects the others. An arrested development in one retards the growth in the others.

In order to obtain the best results the educator must keep constantly in mind the desired product. It is not sufficient to know the subject matter alone; he must study the effect produced on the mind and heart of his pupil. Who would care to employ a physician who was up on materia medica, but short on physiology, and who gave medicines but never took the trouble to note the effect on the patient?

The teacher of physics is especially liable to forget the real object of his teaching in the absorbing interest of his subject matter, or in his appliances. As well may the sculptor forget the image which he intends to form in the contemplation of the quality of his marble or the fineness of his tools.

If the youth has these three elements in his organization and it is possible to add to the development of all three simultaneously by the conscious effort in that direction, then certainly that teacher is best equipped who has that knowledge and applies it. Good is accomplished in this direction unconsciously, but this good can be augmented by the conscious effort.

Did you ever think what a splendid factor for the upbuilding of mankind was introduced by Galileo when he let drop his *bomb* from the Tower of Pisa? The explosion of Aristotelian philosophy that followed shook up the dry bones of the blind worshipers of established authority. The incident was of inestimable value to the succeeding ages and proved a lesson from which it has received large benefits. Much has been written about the renaissance of the classics and the arts and its splendid effect on the European peoples, but how little is said of the no smaller benefits derived from the birth of science. We have but to contrast the conditions of all classes of European peoples

of that day and this to see the value of scientific knowledge. The knowledge of physical phenomena and principles has influenced and permanently affected the life of nations, and has influenced and does influence the life of individuals. In support of the first part of this assertion, I need but call your attention to the knowledge of the use of the compass, the various mechanical devices for transmitting energy, the steam engine, the telegraph, the telephone, the telescope, and the microscope.

It does make a difference what a child studies and how he studies. It makes a difference what experiences he has and how well he understands them. The difference between an average Chinaman and average American is due to the difference in the number and character of his experiences. Each has his own methods of culture.

The selection of any subject for a course of study should justify itself not by tradition, but wholly on the grounds that the experience gained from it uplifts, broadens, and enriches the life of its student. History and science are the two great fields of real knowledge and experience, the world of man and the world of nature. These two at present are gradually wresting from the formal studies somewhat of their prestige and estimation held by course makers. History, including as it does in its broader sense, biography and literature, has come to be recognized in its proper relative importance, but of the place of the sciences I am not so well assured. True it is, in our universities, the number of students taking the science courses is rapidly increasing; but is it because the value of science training is appreciated, or is it because it is a requisite for the technical courses? True it is that the High Schools of the state have within the last few years largely increased their equipment for science teaching through the stimulus of the High School inspection system and examination for the accredited relation; but is not this activity a movement which has been tolerated rather than fostered by school administrators? Science deserves a place out of its own merits and not for any borrowed reason. Kraepelin says: "Nature should not appear to man as an inextricable chaos, but as a well-ordered mechanism, the parts fitting exactly to each other, controlled by unchanging laws and perpetual action and production." And Humboldt says: "Nature to the mature mind is unity in variety, unity of the manifold in form and combination, the content or sum total of natural things and natural forces as a living whole.

The weightiest result, therefore, of deep physical study is, by beginning with the individual, to grasp all that the discoveries of recent times reveal to us, to separate single things critically and yet not be overcome by the mass of details, mindful of the high destiny of man, to comprehend the mind of nature, which lies concealed under the mantel of phenomena." The science teacher, in order to bring about the highest results, must know that the highest purpose in studying science is to get an understanding of life and to see the unities of the universe.

Since the child's public school course in science is usually limited to one or possibly two formal branches of science, that branch or those branches should be chosen which will serve the above purpose best and thus render the highest good for the student in the development of his character. Does physics offer this opportunity?

In the first place, physical phenomena and principles enter more largely into life's usual experiences than any other, and therefore should be understood. In the second place physics affords a large disciplinary value, embracing as it does the practical application of the various branches of mathematics to the organizing and systematizing of the common experiences of life, and affords a means to teach the scientific method of study. In the third place, physics is especially adapted to furnish training into the conception of the fundamental principles of morality. Now, you are wondering if I have a new cult to offer, and I wish to say no to this, but I shall give just a few things that have suggested themselves to me and seem to have value.

Some time ago, while we were discussing the humble beginnings of most great men, a boy in my Sunday School class asked the cause of this. My mind ran out for a satisfactory answer to his question, and as he was a pupil in my physics class I replied that I believed Newton's Third Law of Motion explained it: "To every action there must be an equal and opposite reaction." Adversity furnished the necessary reaction which a character must have in order to have exercise and hence grow. It has impressed me many times that this is more than a mere analogy; that this fundamental physical law is a mental and moral law as well. Strong mental and moral qualities cannot be made unless there is friction along the line which must be overcome. He who always chooses the way of least resistance can never hope to test his mental or moral powers, or to gain

strength thereby. The man who does anything worth while will meet plenty of resistance without going out of his way for it.

What is the law of habit but the law of inertia—the tendency to retain present conditions? A mind which remains at rest for some time will acquire so much inertia of rest that it requires great stimulation from without before motion is started again. When one is made to think deeply and feel strongly about any question, it requires a large amount of activity from without to change the line of thought.

He who fully understands the Second Law of Motion can easily see why there is no such thing as chance, or luck, in this world. Every force has its own effect regardless of its magnitude or whether accompanied by other forces. Every act of a man's life has its permanent effect, and a man is the sum of his thoughts and his deeds together with those of his ancestors. I have no patience with the idea that one man succeeds because he is lucky and another fails because he is unlucky.

> **The luck that I believe in**
> **Is that which comes with work**
> **And no one ever finds it**
> **Who's content to wish and shirk.**

A belief in luck or chance is one of the most demoralizing ideas which pervades the mind of man. His inability to realize the immutability of law that like effects follow like causes, leads him to take chances at the gambling table or the stock exchange. If the young man could be made to realize that these fundamental laws apply to every act of his life, he would hesitate to wreck railroads, water stock, and secure property and privileges without giving value received. "Whatsoever a man soweth that shall he also reap," is what the great Philosopher said. Do we fully understand all it means?

I shall always have my misgivings about that man who, on an occasion when the possibilities of the exhaustion of our energy sources in the form of coal, etc., were being discussed, declared, with much confidence in his solution, that the invention of the dynamo had settled that question since it would take the electrical energy out of the air and furnish power, heat, and light for us. This literary gentleman thus nullified Lenz's law as easily as a city mayor nullifies a gambling ordinance.

This man belongs in the same class with the banker who asked one day while we were discussing the limitations of the electric

automobile, "Why wouldn't it be feasible to have a hand dynamo attached to the auto so that when the charge ran out it could be restored by hand?" The former individual on another occasion said in good faith "that he thought the city water works department ought not charge so much for water furnished to a motor because it could drain right back into the mains."

Another gentleman of my acquaintance thought he had found a financial bonanza in the invention of a tramp whom he had given employment in his factory, and he invested considerable money in experimenting. He described it as a dynamo that was without a field magnet. It had a field magnet which he knew not of—earth's magnetism.

Many a poor man has been driven to the insane asylum while trying to invent some machine which would do work without a supply of energy. Many a man has wasted his fortune or his time and his energy when a little knowledge of physical principles would have prevented such disasters.

Something for nothing cannot be obtained anywhere in the universe. "By the sweat of thy brow thou shalt earn thy bread" is a law written in nature as well as in the Bible. Emerson stated the same truth when he said, "The benefit we receive must be rendered again, line for line, cent for cent, deed for deed, to somebody." In no place is the truth of this made to yield up its full meaning as it is in the Law of Conservation of Energy.

A comprehension of the fundamental physical laws and their application to the common experiences of life and to the motions of the heavenly bodies as well as to the smallest imaginary divisions of matter will help to give men their proper bearings in the world of thought and in the world of business. No knowledge renders the mind so stable, and satisfies it so well as the knowledge of natural law, its unities and its universality. "The heavens declare the glory of God and the firmament showeth his handiwork" to whom? "To him who in the love of Nature holds communion with her visible forms, she speaks a various language."

If the student knows the Law of Conservation of Energy and knows that his being is subject to its provisions and that his body is a machine to transform chemical energy into molecular, mechanical, and thought energy, I believe it will influence him to husband his resources and not dissipate them in the unreasonable pursuit of hurtful pleasures. When he understands that

the laws of his body and of his mind are but laws of matter and energy working in an organism and that he is the product, it will be of more influence than sermons on the evil effects of cigarette smoking or the use of alcoholic liquors. This knowledge may also convince his sister that her stomach is intended for something else than a receptacle for bon-bons, ice-cream sodas, and pickles. "He that defileth the temple of God, him will God destroy." How? By natural law. The body should be treated like a machine, which, in order to give high efficiency, must be given great care and must not be lubricated with sand. Prof. Huxley, in his lecture on Science and Education, gives the following definition: "Education is the instruction of the intellect in the laws of Nature, under which I include not merely things and their forces, but men and their ways; and the fashioning of the affections and of the will into an earnest and loving desire to move in harmony with those laws."

So far I have tried to give a few illustrations of the way in which the knowledge of physical principles might be of benefit to the student, and I have but a few moments simply to mention some of the virtues—moral and semi-mechanical—which can be inculcated by proper laboratory practice. The word "proper" ought to be emphasized, for if laboratory work is not done properly, vices are just as easily inculcated.

Where can you find a better place to train the pupils into habits of regularity, punctuality, neatness, silence, industry, honesty, and self-reliance? Inefficient or careless inspection may lead the pupil into the rankest dishonesty. Sometimes this is the fault of the instructor, oftener it is the fault of the school administrators who wish to make a reputation for themselves along economical lines. A certain superintendent once asked a teacher of physics if he could not conduct a recitation with thirty pupils in one room and a laboratory section of another thirty in an adjoining room at the same time. This teacher refused to be a party to such a farce and he chose the other alternative of having his hours increased to eight periods instead of six per day.

Too much help to the pupil in the laboratory is worse in many respects than too little help, and both are bad. It is a wise teacher who knows just when to give help to the struggling student in order not to thoroughly discourage him, or, on the other hand, to cause him to lean too heavily on the teacher.

Permit me to say in conclusion that I thoroughly believe that it is the duty of the science teacher to study the development of his pupil as well as to study the subject matter, the appliances, and the methods of his subject, and that he has a greater responsibility than merely helping his pupil to a little knowledge and giving him a few mental gymnastics. That teacher who does not see a moral side to his teaching—no matter what his subject—is missing the great opportunities of his lifework.

CONDITIONS AND EQUIPMENT IN SECONDARY SCHOOLS.

By Charles R. Allen.

New Bedford Industrial School, New Bedford, Mass.

It is only proper that I should preface what I have to say here by the statement that it is based on an experience extending over a considerable term of years, but confined to one city, so far as direct experience goes, and to New England so far as direct personal observation is concerned. Nevertheless, reading and discussion with teachers from other parts of the country have led me to believe that, in general, the conditions which I shall discuss are, in the main, typical, and therefore of some general interest.

In particular, I propose to discuss some tendencies which I honestly think tend to bring about conditions which do not make for the most effective teaching of chemistry, and I do this because it seems to me that they can be modified, if not remedied, by the assistance of practical chemists, such as the members of this society.

The subject assigned to me is "Conditions and Equipment in Secondary Schools," but, fundamentally, conditions and equipment are determined, in most schools, by the ideas of those in charge as to why chemistry is given a place in the curriculum. In theory, the reason is very evident: the school aims to acquaint the pupil with as many different fields of human activity as possible: chemistry is one branch of a great field of activity, science—hence, it is properly included in the course of study.

Now this theory is all right, but when we come to practice in the average secondary school, we land with something entirely different from what was theoretically contemplated and from what the outsider often thinks is being done. In my judgment,

chemistry, in the average secondary school, falls far short of doing what it should do, and what it could do, so far as the inherent value of the subject is concerned. I think that this statement may be made to apply to all science teaching in these schools, but since chemistry has a higher potential teaching value than other science studies, this failure is perhaps more regrettable in this case than in the others.

There are many reasons for this failure to make chemistry what it should be, but above all others, there are three: standardization, due to the nature of college entrance requirements, a failure of those in charge of schools to fully grasp the scope of science courses (particularly chemistry) and a failure on the part of teachers to fully realize the nature of the problem involved in teaching this subject to children of the age of those usually taking this subject in secondary schools.

Before taking up these matters in detail, however, I should, in all fairness, say that there are undoubtedly many exceptions to the conditions which I shall discuss—but I am dealing with the general run of things, and the exceptions only go to show how much more could be done were these limiting conditions removed in all schools, as they are in some.

Now, just as to the actual conditions under which chemistry is taught in secondary schools. Leaving out the schools whose sole function is college preparation, we have either the large city school, with several courses, or the small school, with one—in either case, the subject is usually taught in the upper years of the course, to mixed classes, and, since girls stay in and boys get out, these classes are largely girls. In the larger schools, there are one or more teachers teaching the subject entirely, but more often, one teacher has both chemistry and at least one other science, usually physics.

Taking these classes as a whole the bulk of the boys will enter the life of the community without further education and the majority of the girls will eventually become home makers. The chances are 99 out of 100 that not one of these pupils will ever become chemists and the majority of them will never directly use technical chemistry in their lifework.

Now, I suppose that we would all agree that, in general, the school should give these pupils some notion of what the field of chemistry is, its achievements, its great pioneers, the nature of its problems, and the way in which these problems are attacked. Therefore, we do not need to teach them to play the game, so

much as to have some intelligent appreciation of the game, and to realize that somebody must play it in the thousand ways in which this science enters into our life. That is the main problem: to do this with mixed classes, mainly girls, from 17 to 19 years old.

On the other hand, here and there, somewhere in the schools of to-day, are the chemists of to-morrow. Therefore, our courses in chemistry should afford opportunity to develop and encourage such special ability—to direct it, and head round pegs toward round holes.

Now, doing this successfully, is a very different thing from teaching grammar. We want our pupils to know enough chemistry to understand how it enters into our daily life, how it protects us from disease, how it guards the purity of our food, how it acts as our servant in converting the raw material of the earth into substances which aid us in carrying on the work of the world. This means the history of the science, biography, visits to manufacturing plants (if such be available), some training in the solution of elementary chemical problems by chemical methods, and, in general the development of the subject in a broad way, leading rather to appreciation and some comprehension rather than to knowledge of minute elementary detail. The only pupil needing that is the one who has to meet the college requirements.

Now, conditions as they often exist at present, do not make it easy to successfully perform either the function of developing the "hospitable state of mind" toward chemistry or of developing the born chemist. Perhaps the most important of these is the fact that the bulk of the chemical work in high schools is, essentially, college preparatory work, even with non-college pupils. Of course this is not true on paper, but as a condition and not a theory it is often true, and this is bad, not so much because the college preparatory courses are, in themselves planned to be bad, as in the unfortunate point of view, which is introduced, whereby ability to pass an examination in a certain schedule is made the one thing of importance.

In practice, the thing works out somewhat like this: a few pupils are actually going to college. The principal feels (and often with some reason), that the standing of the school depends largely on the records made by these few pupils in the entrance examinations. Nobody inquires about the rest of them. Hence the whole pressure on the teacher is not to teach these pupils

chemistry in a broad way, but to get them through the examinations creditably. Moreover, since there must be about so many pupils in a section (or, in small schools only one class) to these college pupils are, of necessity, added a lot of others who are not going to college at all—but who must be put through the same mill in the same atmosphere.

I once heard a prominent educator say that the cheapest form of education was Latin, that a cheaper teacher could do effective work in that subject with more pupils, than in any other. Now it is difficult to get school authorities to see the economic fact that good science teaching is more expensive than good Latin teaching—they want science, but they shy at the price of good work.

So, it is hard to get them to see that it takes any more time or energy to properly teach a laboratory course than to carry a pure book course. So, if the teacher has any spare time which he could give to devising experimental work or doing a little extra work with a bright pupil, he is often given a class in history or German, just to keep him busy.

The result is, that even if he has other sections in non-collegiate courses, he has to put them all through the same routine and, moreover, is driven to making the whole matter as much of a routine and time-saving proposition as possible.

This leads naturally to the substitution of memoriter work from a text-book for knowledge actually thought out by the pupil himself, to the development of experimental work which commends itself on account of its allowing the pupil to work with little direct aid from the teacher—"automatic notebooks" wherein all the thinking has been done by the author and the pupil has only to follow instructions to successfully do what he should have painfully thought out himself.

All these things are forced upon the teacher because he is obliged to teach a subject which is fundamentally a laboratory study, which is based on knowledge obtained from experimentation only, as if it were language or history, and moreover, as if the whole mass of pupils were to be chemists and develop their knowledge in the advance schools, which the bulk of them will never do.

Now that practically all colleges accept the certificate of the college entrance examination board, the easiest way to fit a pupil for college is to fit for the board of examinations, so that the practical result is that the teaching of chemistry in secondary schools is becoming standardized, and standardized in conformity with the requirements of the examination board.

Now I do not believe that any small group of men, had they the wisdom of Solomon, can standardize the teaching of this subject to fit conditions, no matter how honestly they may try, unless we are willing that the teaching of chemistry should degenerate into a simple cramming proposition, in a universal syllabus, with forty or sixty experiments performed as rapidly as possible and always with an eye, not on educational results, but on the examiner.

Now as far as college preparation goes, the colleges have a right to demand what they choose and standardization means ease of administration, but when the practical result is that the non-college pupils must also be put through the same machine, we have a condition which, I believe, calls for serious consideration from those who would see chemistry fulfilling its true function in the public high schools.

In other words, the non-collegiate pupil should have a fair show, and now he doesn't get it in many cases, because no matter how admirably the college preparatory work may fit for the requirements of the college department which framed it, it does not do the work that should be done with a boy or girl who goes from the high school directly into actual life, and to whom the high school represents the final end of formal education.

A second condition worth discussing is the failure of many teachers to realize that the high school problem, as an educational problem, is not the problem of the college or engineering school. During the years from 17 to 20, boys and girls are developing very rapidly, there is more of a gap between the high school senior and the college freshman than we realize. Yet many teachers feel that the more they can "anticipate" college work, the better work they are doing. So we have a continual tendency to administer merely diluted college work to high school pupils, disregarding the fact that psychologically and pedagogically the problem of the secondary school is vitally different from that of the college, and requires different methods, material and presentation. Here conditions could be greatly improved by the building up of courses really suited to adolescents.

The average principal of a high school, as already stated, is very liable to look mainly at the college preparatory function of his school; but beyond that, he naturally sees things from the administrative side. He often does not see why it is not just as easy to chop a chemical experiment up into 45 minute periods

as a history lesson; why progress cannot be accurately reported in terms of somebody's text-book, and why the formal steps of Hebart's typical lesson cannot be rigorously worked out. It upsets his routine if the chemistry teacher wishes to take a class visiting somewhere outside of the building. He may allow it, but it worries him—it is irregular—hence again a tendency to make the work in chemistry such that it makes the least trouble in the running of the school, not to make it most effective.

In what I have said so far, I have tried to present three reasons which I believe are tending to bring about conditions unfavorable to the teaching of chemistry as it should be taught in secondary school. To meet them, I believe we need education of school administrators, by the suggestion and active interest of working chemists, pressure for conditions whereby at least the non-collegiate pupil can have a fair chance to get a little glimpse into the field of chemistry unhampered by sixty experiments or a universal syllabus, and a greater recognition on the part of teachers that their problem, while as honorable as that of the college man, is radically different.

Now in many cases the teachers know this. They would change conditions if they could, but how can they, unless they gain some support from us? If those of you who are practical chemists would actively take up the matter in your own localities, you could do much good—more than you realize—for school boards are generally very ready to listen to and carry out suggestions from men who have practical experience.

I commend then, to your consideration, these three adverse conditions: increasing standardization in the direction of routine work to meet one point only--college requirements, and those as interpreted by the examination; a feeling on the part of teachers that most efficient work is being done when high school work is diluted with college work; and a failure on the part of administrators to see why the teacher of chemistry needs any different conditions than the teacher of a non-scientific subject, together with an unnecessary hampering in the interest of ease of administration.

Could these conditions be changed, I believe that we should come much nearer, in the average high school, to really opening up to the pupils something of the history, the romance and the vital connections with our civilization of one of the most fascinating of the sciences, instead of being in danger of making only another routine grind.

THE FIRST COURSE IN CHEMISTRY.[1]

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In school work, the teaching of any branch is not an end in itself, but one of the means employed in an extended system of education. We do not drill our pupils in drawing, music or Latin with any idea of cultivating artists or linguists, but because these subjects serve certain purposes in the general educational scheme. As applied to our subject, especially in the introductory course, the object of the work should not be to teach chemistry so much as to teach boys and girls such facts and principles concerning chemical phenomena, as, with the time and material at our disposal, will best meet their needs. Any technical or mercenary advantage which might be derived from the study of chemistry has but little consideration in the educational scheme, but our present social development depends so largely on applied science, no one can understand it unless he knows something of the general principles of chemistry and physics.

It is customary to discuss the educational process from three points of view: the ethical, the disciplinary and the informational. Yet, when we come to consider them practically, we find that we must take them in the reverse order; acquire knowledge concerning the world, be able to use our common sense and bring our knowledge to bear in working out the tasks in hand, to place a proper value on what we know or experience and to apply such conscientiously and honestly in life.

How far chemistry will or can contribute to this will depend on the teacher, the pupil and the content of the course. So that the question arises: when, how and what chemistry should be taught in our secondary schools?

Inquiry among chemistry teachers shows practical unanimity; everybody ought to study chemistry. This would necessitate chemistry being placed early in the course. On the other hand, most teachers want it after the pupil has studied physics, when the pupil is more mature; this would bring it at the end of the course and confine it to the few. There must be something about chemistry of fundamental importance if everybody *ought* to study it, and there must be something abstruse and difficult if it *can* be taught only to the elect.

[1]Read at the Boston, 1909, meeting of the American Chemical Society.

The superabundance of chemical phenomena and products daily thrust upon our attention, testifies to its importance and a study of matter might easily compete with nature study of the lower grades. The difficulties of the subject are largely artificial, due to the acceptance of traditional methods of presentation especially of illustrative material. Why, in so many books is the law of multiple proportions introduced in connection with the oxids of nitrogen? Why is the law itself so expatiated on? If the atomic hypothesis is accepted, this law is a necessary conclusion and of no more importance than many others that receive scant attention. It has played an important part in the history of chemistry, but the historic order is not necessarily the best and we are not fair to the pupil if we refuse to use modern facilities merely to preserve historic form. Many of the beacons set up years ago are now outside the main channel; it is possible we may map out a new course and so plainly mark it that school children may follow it.

Our course on the disciplinary side must tend to develop an appreciation and an interest in current developments, compel telling the truth, lend ability to handle such problems as naturally arise, to weigh evidence impartially and intelligently interpret it in good English; this last is not least important. To accomplish this we must have a strong foundation of facts and a good teacher. We must build our own foundation. For one fact we may prove we must accept hundreds beyond our skill or means. We must learn what others have done, learned or thought. The first lesson of the child in school is to obey, to respect authority. It is impressed upon us in life we cannot act or think independently. The vast majority of our pupils will not be leaders in life, they will not be called upon to plan, but to carry out the plans of others. To succeed in life they must know the leaders and yield obedience to constituted authority, whether it be in the political or scientific world. It is this which is most liable to be slighted in our so-called inductive courses. A course that claims to be disciplinary and fails to impress this is worse than useless. It is injurious in that it develops a type of skeptical egoists whose cry is, "Show me." They contribute nothing to the social good and decry honest effort.

While the study of systematic method and the development of systematic habits and personal honesty are most desirable their usual concomitants, technical measurement and manipulation are of very minor importance and are of value only so far as they

contribute to the creation and fixing of honest habits. The so-called scientific spirit as displayed in our greatest scientists was not instilled by formal instruction but developed by habits of neatness, orderliness, attention to details, and **especially by concise, honest, and accurate expression** of ideas in language. Scientific method is based on the experience of the race, but it is not the way the individual works; life is too short to learn much at first hand so we must accept the experiences of others. The successful man, the genius, is the one who combines and brings to a practical result the work of his predecessors.

If we examine the content of our science, it is appalling, fact after fact come forward claiming attention. It is evident that at best we can but scratch the surface in the year of perhaps 150 hours allotted to chemistry. Where shall we begin? What shall we leave out? Roughly, we may divide the work in two parts; the descriptive side which deals with facts, sequences, and values as perceived by our senses; and the theoretical side which deals with the translation of these into the terms of those mental forms we have constructed. If we leave out the descriptive part we have no basis for the theoretical except from a mathematical standpoint. If we leave out the theory, apparently we make the work disjointed, empirical and not scientific.

Although we always teach with a view to culture, our ideas of the relative value of the content have been subject to change and it is coming to be more generally accepted that culture is best obtained through the study of such things as bear most directly and naturally on the pupil. Such material we find on the descriptive side of the subject. Theory is not fundamental in the progress of science, it comes and goes as the science develops. It is the polish which fills out and hides the gaps in the line of facts. It is attractive to our cultivated tastes. We like it because we made it. We saw it grow. To the beginner this is not so. Deprived of its personal application to the pupil, chemistry deals with mathematics and abstractions. To comprehend many of the most simple conceptions of chemistry, requires a more vivid imagination than is called for by any other branch of science. It is utterly beyond the average high school pupil and indeed of many college men. Our familiarity with the subject hides from us its difficulties to the pupil. John Dalton would not accept literal symbols instead of his own ideograms. As late as 1837 he wrote, "Berzelius' symbols are horrifying. A young student might as well learn Hebrew as make himself acquainted with

them. They appear to equally perplex the adepts of science, to discourage the learner as well as to cloud the beauty and simplicity of the atomic theory." The history of chemistry is full of instances where masters of the science have been unable to grasp theoretical conceptions we lay before our pupils as matter of fact.

Suppose we admit the possibility of teaching such theoretical ideas, is it worth while in a first course? If it is learned, it is as a matter of memory and useless. To derive the atomic theory from the laws of Dalton requires subtle argument, it is not for the child. Our best text-book authors use Avogadro's hypothesis as a big stick, yet they often sneak it into the text in a most unscientific manner. Our ordinary courses and texts, like Topsy, just growed. Usually elements or groups of elements are taken up first, as to occurrence and preparation then properties, compounds, and use. Almost all chemistry text-books follow this arrangement; where we find it, how we get it, what it is like and what it will do. It sounds well, what is the matter with it? I presume I shall be taking the bull by the horns when I say it is not pedagogical and not scientific. Apply it to sodium and see the result. Suppose we change the order of presentation; sodium has certain characteristics, it reacts thus and so, furnishing products with certain peculiarities. Having studied the compounds we can teach *why* salt occurs in nature, perhaps that it might be expected to occur. *Now* the pupil can undertake to learn how it is isolated and the reason for such procedure. This is logical and scientific, but, is it practical? In the case of sodium as I have outlined it, it is not, for this reason, I have brought no connecting link between the pupil and the subject and until I can furnish such a connection I would not make the element sodium a chapter in the course.

At the Baltimore meeting of the American Association for the Advancement of Science there was a rather pessimistic paper on the Problems in Science Teaching with especial reference to chemistry. Now, I do not think it is a condition to be despaired of. I believe we can put a large amount of chemistry, far more than we have time for, within the reach of far more pupils than at present, if we but step aside from the traditional position and look upon the content as the child will. Words, definitions and laws contribute nothing. The training that contributes to culture and efficiency comes from the content and this must be intelligent to the pupil. We know the pupil will not voluntarily respond to

the task unless the problem appeals to him as worth the effort. The question ever on the lips of the student is, "What's the use?" If we anticipate and find connecting links between the pupil and study we will secure his coöperation in the beginning and before he knows it he will be so hard at work he can't back out.

Education must be conservative, it must not react to fads and fancies however attractive, but in view of the criticisms of science teaching in general, and above all the social needs of our pupils demand such change in our methods as will make elementary chemistry teaching more efficient and general. There is a demand for what some call practical instruction. If we examine it we find that so far as chemistry is concerned it is not practical at all, in that it is a demand to teach technology. It is in the power of this society, it is its duty, to pay attention to the way chemistry is taught to the masses and not leave it to self-constituted authorities.

I do not advocate bread and butter chemistry, teaching chemistry as a trade or to ape the methods of schools of technology, neither would I have it purely informational—many of our textbooks are merely information. In dealing with students many of whom will receive no farther science teaching, I would so far depart from the old methods as to teach *topics* rather than elements. Discuss phenomena and problems such as naturally arise in connection with subjects in which we are interested. Not catering to curiosity yet confining the content to matters which the pupil might be expected to comprehend. If the pupil does not understand the material before him it is the wrong material or wrongly presented. The content should be chosen from the side of the pupil regarding his capacity and wants, to develop him rather than to develop the subject. The metallurgist does not think in atoms, but in tons. The engineer measures pounds, not molecular bombardments. Empirical application has nearly always preceded pure science. We must teach pupils to think in masses before we attempt abstractions; to attempt both inevitably leads to confusion.

Aside from some sporadic skirmishing nearly all text-books get started at the same point, a chemical change and a chemical compound. The chemical compound is a substance that has definite composition by weight (they always put in the *by weight*). For the chemical change, they are less definite, they do not seem to be able to put their meaning in words, they expect the student to absorb it from illustrations. For this the sulphur-iron stunt is

the most popular. The ordinary pupil knows nothing of sulphur, little more than the name of iron, as for the product—the less said the better. So far as the experiment is concerned the pupil might as well have used glue or sealing wax as sulphur.

If we want to begin here why not do it sensibly, using things and language the pupil can understand? Teach this idea truthfully *as you understand* it and not rehearse an old formula. If this idea of a chemical compound is to be the starting point it is better that it be taught in connection with something worth knowing. Take water from the tap, freeze it, you can see segregation and changing temperature. separate and refreeze until segregation stops and we have constant freezing temperature. Distill in same manner. Get pure water. Study its properties. Here is the practical isolation of a chemical compound. A chemical compound is a substance having *definite properties*. Its composition, by weight or otherwise, is but one of its many properties. You recognize substances preferably by their physical properties, appearance, form, density, melting or boiling points, since these are definite. You consider yourself in hard luck if you have to determine the composition by weight, in order to identify a material. Since *you* do not use the definition why insist that the pupil start with it? He will never use it.

In the practical recognition of water, many facts will be brought out which will aid later work. Distillation, solidification, boiling and freezing temperatures and their variation have been touched upon, not made subject of theoretical study or explanation, but *introduced* in such a way that when they come up again the pupil will have some facts to bear on the new matter. Instead of being disjointed the topical method will find its connections in the pupil. It will furnish abundant opportunity for that repetition so lacking in our teaching. The same substances and the same processes will come up again and again, slightly changed in aspect as seen from a different point of view, but recognizable and ever widening the view, contributing to efficiency.

For many years hydrogen was the first element taken up in the texts. Of late years oxygen has moved up to first place. It is convenient that the student should know something of oxygen early in his course. It is important that what he learns should be the truth, and in the beginning confined to what is worth knowing. Practically all that an elementary student need know about oxygen will come out in its proper place and at its proper value if we study, not oxygen, but *burning*. Oxygen is important

not for any properties it possesses as an element but in its reactions with other substances. It is but one of the factors in combustion. Study the process of burning of common fuels, solid, liquid, and gas, as we meet them in our stoves, lamps, and burners. Find the conditions controlling the temperature or light, the products of combustion, their character and disposal.

Of course this is not a complete study of oxygen; it does not pretend to be. It is a study of the principles involved in reactions in which oxygen is a factor. When new properties of oxygen are needed they will easily fall into their proper place among these. So we might extend the topics, studying not the elements but their applications. Silver, as a metal, should not come in the same chapter as photography, but with gold and copper. Teach the metals as metals and their compounds where they belong. The uses of lead should not be confined to a small paragraph at the end of the chapter, but we may start with them and ascertain what properties lead possesses that it may be so applied.

In conclusion: The first course in chemistry should be adapted so as to be within the capacity of any child in the high school.

It should be designed for the many rather than the few.

It should be broad rather than deep.

Its content should be such as to give a comprehensive view of the general principles involved in ordinary chemical phenomena and some knowledge of the sources, preparation and utilization of commercial products.

Its method should exercise the pupil in careful habits of work, accuracy of observation and truthful expression.

Its aim should be to promote personal honesty in thought and deed, and furnish a workable knowledge of the world.

For the pupil who will continue in school such a course will serve as a foundation for more intensive work. The pupil who does not continue will have had his interests aroused to increased efficiency. He will not think that his time was wasted; a mite will have been contributed to his happiness.

THE USE OF QUALITATIVE TESTS OF FOODS IN TEACHING GENERAL CHEMISTRY.[1]

By John C. Olsen,

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A thorough discussion of my subject involves the consideration of a considerable number of questions with reference to the teaching of General Chemistry. In the first place, we cannot reach a correct decision with reference to the inclusion of qualitative tests for foods or any of the almost innumerable technical applications of chemistry unless we have clearly before us the objects to be attained by the study of this subject.

In the first place, the making of professional chemists is *not* the object of teaching General Chemistry. Even in our colleges and technical schools, only a very small portion of the students taking general chemistry become professional chemists. Most of such students are taking engineering or culture courses. In high school classes, an even more minute proportion of the students become chemists. The needs of the few who in increasing numbers *do* choose this science as a life career must, of course, not be overlooked, especially because the inspiration to make this choice is often obtained in the general chemistry class room.

On the other hand, chemical principles and facts are of the greatest value in many other professions than that of chemistry. The lawyer, the physician, the business man, the mechanic, not to mention the mechanical, electrical and civil engineer, can frequently use to the greatest advantage every scrap of chemical knowledge they possess. As one industry after another has come under the control of the chemist and as he has produced one useful product after another, it has become more and more difficult to find a trade or profession to which chemistry is not an ever ready handmaiden. Chemistry may, therefore, be said to be an essential part of not only a liberal but even a scanty education; for who can be said to be educated who has no conception of the nature and constitution of the material objects around him or the processes by which almost all of the energy at our command is obtained? Let me remind you that this includes not only the operation of the steam engine and the

[1]Read before the Chemistry Teachers' Club of N. Y. City, April 2, 1910.

dynamo, but the muscular force which wields the shovel and the mental energy which directs our complex life and writes our literature. The energy for the work of the poet, the artist and the artisan is all obtained from chemical reactions.

In order that the teaching of general chemistry shall attain this end, that is, furnish a useful handmaiden for all the arts and professions, the conceptions of matter and energy which it presents must above all be as true to nature as our present knowledge permits.

This leads to the third object to be attained in teaching the science—namely, the development of the experimental method of ascertaining truth which has enabled us to make the enormous strides in the science which will always characterize the century in which we live. We are masters of the experimental sciences as the peoples of other ages have been masters of art, law, religion or literature. As we to-day can hope to equal but not surpass the great sculptors of Greece, the law-makers of Rome, the artists of the middle ages or the literary productions of a Shakespeare, so future ages will consider *us* the scientific and industrial giants who could manipulate the forces and raw materials of nature to suit our fancy without looking, consciously or unconsciously, to any master of the past for guidance.

No science is so well adapted as chemistry for giving to the rising generation a glimpse of this master spirit of the age. Not only is it possible to give the experimental proof of every statement made, but such epoch-making discoveries as that of radium and the decomposition of elements are made under our very eyes. The daily newspapers announce the discoveries in their headlines; and the story of how the startling observations were first made may be heard by many of us from the lips of the man who made them. "The man on the street" knows under these circumstances that chemistry is a *living, growing* science, in which few tenants are final. I fear that the stimulating inspiration to be found in the study of such a science is frequently lost to the high school boy when the teacher of chemistry presents as a *finality* the observations and especially the theories and deductions of our science. The *method* of making the observations and reaching the deductions and building the theories is of far greater value than the facts which we so soon forget and the theories which we cast aside almost more rapidly than the hard-working teacher can hammer them into the reluctant

minds. I am not unaware that this same hard-working teacher declares in despair at hearing such a statement that "it is utterly impossible to attain any success in teaching a science in which such kaleidoscopic changes are possible. If everything changes so rapidly, *what can we teach?*" I reply, *Show your class how the kaleidoscope is built and how it works.* There will be no lack of interest, I assure you. 1st. Teach observation. 2nd. Show *how* theories explain observed facts. We can be perfectly certain of observed facts. Our theories must be changed as new facts are observed. The composition of water has not undergone any change in the last century, and yet the early chemists assigned to it the formula HO, while we are *very positive* that H_2O is correct. They used *8* as the atomic weight of oxygen, while we feel more or less certain that it is *16*. If we succeed in making a sharp distinction in the consciousness of our pupils between the *facts observed by their senses* and the *theories* evolved by the *imagination,* we will confer a benefit which will far outweigh any loss due to many errors in their idea of the chemical *theories* which happen to be in *vogue* when a particular class studies the subject.

Finally, I wish to say a few words with reference to the permanent interest in the subject which should be developed during the early instruction in chemistry. No teacher can be called successful unless at least a few of those who are instructed become so thoroughly interested that they devote their lives to chemistry. I believe that the development of enthusiasm for a subject is an important part of the work of the teacher, especially in the high school. The college, technical school or university will readily make up any deficiency which may exist in the high school boy's conception of the atomic theory, the ions, or the chemistry of chlorine or any other chemical element. If the enthusiasm and interest in the subject are lacking, the high school boy may never *enter* the higher school as a student, much less continue his study of chemistry. There is a serious danger to the high school student, however, who has spent something more than the average time on chemistry in the preparatory school. He may enter the college with a greatly exaggerated idea of his own attainments in his chosen subject. It may be necessary for the college professor to give him many a fall ere he learns his own weakness and limitations, with the loss of much valuable time. An important object of the course in general chemistry

should be the opening up of the boundless stretches to be traversed by him who hopes to make this subject a specialty. The testimony of the investigators who have made the longest excursions in this branch of knowledge, is that as far as the eye can see, there are limitless fields to explore and rich treasure to discover. The teacher who can give something of this vision to the class in chemistry will find many a volunteer to do exploration work and will hear no complaint of graduates who think they know it all.

Having given an outline of the objects to be attained by teaching chemistry, we are prepared to discuss the means by which the objects may be attained. I shall endeavor to show how qualitative tests for foods may be used to attain the objects which I have outlined.

In the first place, it is not the object to make food analysts of the class in general chemistry. It is not at all essential that all the tests for a given food product be given or that the test as performed be conclusive as to the purity of the food tested. For the same reason, the members of the class would not be able to undertake the manufacture of sulphuric acid after studying that very essential subject. In both cases they are amateurs who study the applications of the subject on account of their interest and delight in the science itself.

These qualitative tests are of value because they show how chemical principles may be applied to practical problems in human life. A very simple illustration of this is found in the use of the cost of food constituents for the detection of adulteration. At first sight, this does not seem to be a very scientific method of testing foods. But I am willing to assert that it is fully as logical and reliable as many chemical tests. We can be very certain that a substance will not be used as an adulterant or a substitute if it is more expensive than the article for which it is substituted. The assistance given to the chemist by practical considerations of this character are often of the greatest value and save him a large amount of unnecessary labor.

Qualitative tests are admirably adapted for stimulating observation. The behavior of a given element will be scrutinized with unusual care if the object in view is to ascertain if that particular element is present in an article of food. It is of the greatest importance, however, that the pupil be given the proper foundation for making a test of an unknown. The behavior of the

substance sought for must be first observed by experimenting on known substances. The characteristic behavior of the substance tested for must be brought out clearly by the comparison of material containing it and material from which it is absent. The confidence of the pupil in the test must be established by applying it to samples in which it is present as well as to those in which it is absent.

If boric acid is the element to be tested for, its reactions are first shown, such as flame test and turmeric test. Milk known to be pure is then taken and small amounts of boric acid added and the test applied and comparison made with the same test when applied to the pure milk. The pupil may then be given milk which may or may not contain boric acid but of which he is ignorant. If he can, by test, pick out the preserved samples, he has correctly comprehended the method and will be delighted with his skill and knowledge and will have acquired a new sense of the constancy of his chemical reactions and will have a feeling of mastery of his subject which is very stimulating to his work.

It may be objected that this method of procedure is too lengthy and that the unknown must be given directly without the preliminary tests on known samples. I have no hesitation in answering that if sufficient time is not available for giving the proper preliminary instruction, so that the pupil understands clearly what he is doing, *then the test should not be given at all,* as more harm than good is done. Better let him spend his time making pie, cake and candy after the manner of the average cook without knowing the why of anything done except that the product tastes good.

One of the chief advantages of the use of these qualitative tests for foods is to be found in the interest aroused in the subject by their introduction into the course. This interest is common to the study of all substances entering into everyday use. It must by no means be forgotten, however, that this interest cannot be maintained when we make such substances the subject of study unless we can make a definite addition to the student's knowledge of the substance studied. The most unskillful manipulation of bromine is interesting because everything about this substance is new, but if a common substance like milk be the subject of experiment, something new must be presented or the subject soon becomes a bore and the class loses respect for the instruction.

(*To be continued.*)

THE TEACHING OF THE SHAPE, ROTATION AND REVOLUTION OF THE EARTH IN THEIR EFFECTS UPON CLIMATE AND LIFE.

By Harry M. Clem,
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For a long time in the past, if less in the present, the portion of the subject geography that was dealt upon longest and most fondly and was teased until it gave up its very minutest detail was mathematical. The child was coaxed to try to imagine the solar system and even the fixed stars in their inter-relation and all the refinements of revolution, inclination, parallelism, latitude, longitude were devotedly and devoutly studied. And, after all, why? Principally because the astronomers and mathematicians were the earliest investigators to provide schoolmasters with geographical matter for pedagogical purposes. The geologist had not revealed many valuable pieces of earth knowledge that appealed to the geographer in the grades. The botanist, if he knew the geography of vegetation, presented the geographer with the mere facts concerning the location of a few interesting plants. The zoölogist supplied him with only a few descriptions of interesting animals, not recognizing then, and scarcely now, that each animal is a denizen of the earth and a product to a large degree of his environment. The anthropologist told him only scattering details of a few peculiar tribes or races, and did not then, and scarcely have begun now, to tell him the geographical reasons why men live and labor as they do to-day. Historians only vaguely recognized that the story they told was enacted by earth-born men on a terrestrial stage whose settings fearfully and wonderfully affect their actions. They were a sort of Ben Greet Woodland Players without stage accessories. In religious circles faces were lifted skyward and there was no Dr. Haddon to proclaim of religion. "No longer is it possible to disassociate religion from geography." The professed geographers themselves were at fault, for they were not prepared to define their own subject closely and to suggest fruitful lines of research and to demand proper geographical data from men working in other lines of science.

Compilers of text-books, the "mere geographers," took the line of least resistance and emphasized the hint given them and went to seed on mathematical geography. The map-makers as their art improved came to their assistance, and the location

of places helped out the variety. The problem was a geographical discovery that had not yet been made.

They taught the best they had. To-day, however, the geologist, physiographer, botanist, zoölogist, anthropologist, and all the other learned investigators, are turning up other geographical facts of a flavor as rich or even richer than those of the mathematical variety. Even such elusive quantities as poetry, art, sociableness, mental dispositions, are being subjected to scrutiny for the purpose of discovering their debt to geography. The facts of climate and of life, plant, animal and human, are now claiming attention and warm interest, and mathematical factors are taking their proper perspective in the background of all the other geographical factors.

Not long ago a prominent geographer suggested in a private letter that we might even take the question of change of seasons for granted, and save the time for other lines of the subject of geography. What a long step from the trodden path of mathematical geography of only a few years ago! And he did not make this statement because he is not successful in his teaching of the subject. He suggested it because he is full of the new thought of geography that life in its relation to physical environment is the vital and important line of interest; that a tropical forest, a shred of reindeer moss, a sprig of edelweiss, a camel, an eskimo, a primitive clay jar, an Arabian lyric, is pretty largely what it is because it exists in a peculiar physical environment, where it is affected by such persistent and tangible quantities as elevation, light, temperature, wind, humidity, food, etc.

It is not incumbent upon us, however, to take our shears and snip out the mathematical chapters of the geography. They are valuable; why not use them properly? Why not take the facts of shape, size, and motion of the earth and carry them out into their results on climate and life, thereby establishing the fundamental conceptions of geography while the more mechanical portion of the subject is being taught? The idea is equivalent to that of solving mathematical problems as the characters and principles are learned. The teacher will need add only a few facts, which are usually left out; he need only make applications to climate, life and human culture, as he proceeds with the mathematical phases of the subject. This brief paper is written for the purpose of showing how these fundamental elements of the subject may be related to the more vital things of climate and life as they come in the province of geography. It may not be

new to every teacher, but it is hoped that it may be suggestive to many, and it is designed to give the teacher an outlook ahead into his subject rather than a set of lessons for any certain class of pupils. The teacher may be trusted to present the facts as he sees fit and is able to do so.

There is no doubt that too much time is spent in teaching too many refinements in mathematical geography. There are numerous schemes for presenting the subject in our pedagogical journals, some good, and others useless, or worse than useless. Many are timekillers and mental bewilderments. Any scheme or set of directions that leads the teacher to worry the children by having them imagine certain sets of complex conditions that do not exist merely to show what do exist, does the pupil great wrong by adding to the useless complexities of the subject, by snapping interest and by wasting precious time. Be direct. Teach what is actually true and teach it simply and only in such broad detail as is useful in later geographical study, and teach it in broad detail only. Refinements and conundrums have no place unless the teacher wishes to kill time or desires to gratify his own proclivities to indulging in "smoke rings" of mathematical and astronomic speculation.

Before giving a prescription for teaching the subject, a few observations concerning the aim are in order. The facts of the mathematical portion of the subject, however interesting they may be, are not being learned by the pupils for their own sake. They are to serve as a background to the more vital phases of geography—those of climate first, and then those of life—plant, animal, and human. For the present the distribution of heat is most vital, and depending upon heat and following it are winds, moisture, plant, animal, man, and man's culture—a logical sequence that is primarily affected by the shape and motions of the earth. A flat earth or a motionless earth, giving a different distribution of heat, would change all the other factors in the physical environment.

In order to render the discussion clearer, it will be helpful to bear in mind that there are two elements in the problem, both of equal importance. They are:

1. The difference in the heating power of rays of different slant when they are of the same cross-section or area.

2. The earth as to (a) shape, and (b) two of its motions, rotation and revolution (with inclination and parallelism of its axis).

The Sun's Vertical and Inclined Rays and Their Effects.

If the reader will pause to recall what the text-books say of the vertical and slanting rays, he will remember that it was very meager. They do not enforce the notion that the question of the ray is the chief question in the distribution of heat over the face of the earth. If the slanting ray were as effective as the vertical ray, the entire face of geography would be changed. Polar and equatorial regions, other things as they are, would be alike; morning could as well be noon, and winter usurp the place of summer. But such is not the case, and the difference in the heat effects of vertical and slanting rays must be distinguished, for they are literally a question of life and death. As a single illustration of the effects of the northward and southward pendulum-like swing of the sun's rays over the steppes or grasslands of Western Asia, Brehm's picturesque description may be quoted: "Perhaps it is not too much to say that the contrasts of the seasons are nowhere more vivid than in the steppes. Wealth of bright flowers and desert-like sterility, the charms of autumn and the desolation of winter, succeed one another; the disruptive forces are as strong as those which recreate; the sun's heat destroys as surely as the cold. But what has been smitten by the heat and swept away by raging storms is replaced in the first sunshine of spring; and even the devouring fire is not potent enough wholly to destroy what has been spared by the sun and the storms." The annual variation in the slant of the much-inclined ray is the basal cause of the terrible cold of north central Asia with its two hours of daylight, and of its short, hot summers with twenty-two hours of sunshine.

Without stopping to give devices for teaching the heat value of rays of different inclinations, it is sufficient to note that it is a question of comparing the areas of cross-sections made when a ray of given diameter is cut across at various angles. A lead pencil cut squarely across reveals less surface than when it is cut at an angle. A hollow cylinder held so that it is parallel with the sun's ray will cast a round shadow on a piece of cardboard held at right angles to it. If the paper is tipped the circle becomes an ellipse growing longer as the cardboard is tipped at a greater angle. If solio or blue print paper be substituted for the cardboard, the time for coloring it will be longer the more the paper is tipped from a right angle. The ray as it

increases in slant acts on the principle that a given amount of butter will be thinner, the larger the piece of bread which it is made to cover. With Dr. Goode's "Sun Board" actual measurements may be made of the heat value of the ray.

Shape of the Earth in Its Relation to the Distribution of Climate and Life.

The facts regarding the shape of the earth may be taught when the instructor pleases, and how he pleases, for it is immaterial for our purpose whether he formally pronounces it an "oblate spheroid" or unceremoniously dubs it "earth-shaped" (A. Murray). But it does matter how he traces its influence upon the distribution of light, heat and other geographical elements. The pupils having in mind a correct conception of the significance of the slant of the sun's ray, may now be asked, "Why are morning and evening of a normal day cooler than noon?" The answer will be that the ray is more nearly vertical at noon than in the morning or evening, when, indeed, the rays are tangent. "Why are the polar regions cold while the equatorial region is very hot?" The question is once more one of the slant of the sun's rays, for the slant of the ray, other things equal, is the shorthand expression of the comparative quantities of heat received by various localities. The question is raised, Why are the rays more slanting at some places than others? All the sun's rays may be regarded as parallel. If the earth were flat, then, all the rays being parallel, they would all possess the same degree of inclination and all places would be equally hot or cold. The present polar and equatorial regions would be alike, and morning, noon and evening temperature could not exist at the same moment as they do under present conditions. But we know that the surface is curved and the pupils may be directed to look there for the answer to the last question. Starting with the point where the ray falls vertically, the surface of the earth gradually curves away in all directions, and as it curves away the rays grow more slanting.

At a point one fourth of the circumference (90°) in any direction away from the point of contact of the vertical ray, the rays become tangent. The polar regions are for this reason, then, cooler than the equatorial region, and for the same reason the morning and evening points are cooler than the noon point. The poles with tangent rays, on the equinoxes, are like the morning, and the equatorial region corresponds to noon. The

mornings along the equatorial belt are not so cold as the polar regions simply because the ray is tangent or nearly so for only a few minutes, at any one spot, while it is tangent or nearly so at the poles for weeks or months.

An interesting application regarding the distribution of light and heat over the earth can now be made. Let the pupils, Joshua-like, command the sun to stand still, or in other words imagine that the earth does not rotate (or revolve about the sun) and that it remains perfectly stationary for a time without limit. This assumption is not difficult, for it is similar to a photographic snapshot of a moving body, catching and preserving a momentary attitude for all time. The pupil can catch the geographical factors in action and can study their work in a simple form carried to extremes.

Since there is only one vertical ray it would remain playing for time unlimited on one and the same spot. Shining without cessation, it would always be adding more heat than would be lost, at least for a long period until the earth would absorb no more and a steady flow of heat equal to that received would be radiated into space or carried away by the winds. How high the temperature would be is a matter of speculation. It certainly would become hotter by far than the equatorial region is to-day, and it is probable the heat would become unendurable for plants and animals.

Now imagine rays falling equal distances from the central heated spot. A ray falling 23½° south of the central hot area would have a slant of 66½°. In like manner would a ray falling north or east or west or in any other direction from the center have a slant of 66½°, and the points where these rays fell would form a circle. A cylinder set over a globe of larger diameter will illustrate the idea. Another case, using miles rather than degrees: 2,000 miles south or north or east or west or in any other direction, the ray would fall in a circle, would be more slanting and consequently yield less light and heat. Again, about 6,000 miles in any direction away from the hot center the rays would be tangent or nearly so, falling in a circle and giving less light and a lower temperature than the other steeper rays.

The teacher should pause here to induce the pupils to imagine clearly the situation, for it is important. The pupils might imagine themselves far out in space and in line with the sun, looking toward the earth at rest, bathed in a cap of light glowing

strongest at the central point where the vertical ray falls, and diminishing thence equally in all directions until at the edges it faded into twilight and finally darkness. Then they can be shown that the temperature corresponds to the degree of light, high where the light is strong, low where the light is dim. These relations may be shown advantageously on a black globe by coloring a spot, say, dark red, shading it off through yellow to blue through one fourth of the circumference of the globe.

We might realize the idea more clearly by using our old terms and saying that the heat (and light) is distributed in zones. The zones are then concentric rings, the hotter in the center, bounded in succession by a cooler and a cold ring, and we might speak of them as tropical, intermediate (temperate) and frigid. It must be understood, however, that the temperature of these concentric zones is higher than it is in the corresponding zones at present.

On the opposite side of the earth darkness would prevail, and the temperature would be very low, far lower than any degree of cold that we experience on the earth to-day, but we cannot and do not need to be certain of its exact degree. With such unequal heat conditions on opposite sides of the earth, the circulation of the atmosphere would come in for consideration. Leaving out chemical changes that such heat might produce, and the moisture which would vary as we assumed the presence of bodies of water in the hottest zones, the mere question of circulation would be unique and interesting. Without explaining the causes of air circulation in detail, the teacher can depend most upon that of unequal heating and can easily make the pupils understand it, or he can assume it and state the circulation. The intense heat under the vertical ray would expand the air and decrease its density, while on the side that endures perpetual cold the air would be abnormally dense and heavy. As a result air would flow from the cold portions of the globe radially into the hot, and there, pushing up the lighter, expanded air, would start and continue as upward drafts, which, cooling as they rise, would flow radially away overhead to the colder portions. The velocity of the winds might be very high. The rainfall would be a question of assumption of the area and location of land and water bodies. However, the cooling ascending currents over the central hot area as in the equatorial region to-day, would produce rain if the air contained moisture. Local rainfall

would depend upon local conditions which it is unnecessary to consider in our general treatment.

Under such a situation as we have assumed, the conditions favoring life cannot be accurately thought out. But we can imagine that there will be a different kind of life in each concentric zone as there is at present in our east-west zones. Even if our known tropical vegetation could not grow in the hottest spot on the earth, the area in the region of the vertical or nearly vertical ray, they might possibly grow in a circular belt around the most torrid area. At present the tropical zone is a belt 25,000 miles long reaching around the earth, but on our unmoving earth it is a disc with smaller area. Then outside of this warm belt there would be a temperate or intermediate ring of vegetation. The zone of wheat and rye and maple and oak would run not in two separate belts east-west, one north and one south of the equator, but in a ring around the torrid belt. The grazing animals such as the cattle, buffalo, guanaco, zebra, antelope, and the woodland animals like the wolf and fox and black bear, would be herded or hunted in a circular belt. So, too, the cities and states of an intermediate belt would run about the tropical center. What might be called a frigid zone would be the largest ring, fading away into the twilight behind the earth, and in it would be found icebergs, polar bear, and people living like the Eskimo.

For the sake of realizing the ideas more fully, let some point on the earth be selected as the focus of the vertical ray. Suppose Guiana is selected. This region would be far hotter than it now is; probably even tropical vegetation could not withstand the heat. At the other extreme the tangent or nearly tangent rays would fall on N. Canada, Iceland, Central Europe and East Africa. The sun would always be low and much of the land in twilight. Peary and Shackelton could make what is equivalent to Arctic explorations in this cold twilight belt through Germany, Palestine and East Africa, where now Roosevelt hunts the big game of the savannas and grasslands. The belt of large cities would bend southeastward through Spain, Algiers and Sahara and West Africa. China would be a land of dark and terrible cold, with not a trace of living things. The teacher must be cautioned not to make too precise a determination of the life of these zones, for we do not have accurate facts in the case and are only trying a general hypothetical condition in order to see the broad influence of earth-shape alone.

(*To be continued.*)

PROBLEM DEPARTMENT.

E. L. Brown,

Principal North Side High School, Denver, Colo.

Readers of the magazine are invited to send solutions of the problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to E. L. Brown, 3435 Alcott St., Denver, Colo.

Algebra.

207. *Proposed by Franklin T. Jones, Cleveland, Ohio.*

Extract the cube root of $2\pm 11\sqrt{-1}$.

I. *Solution by Orville Price, Denver, Colo.*

Let $x+\sqrt{y}=\sqrt[3]{a+\sqrt{b}}$. (1)

Cube both members of this equation;

then, since $x^3+3xy+(3x^2+y)\sqrt{y}=a+\sqrt{b}$,

therefore, $x^3+3xy=a$, and $(3x^2+y)\sqrt{y}=\sqrt{b}$;

also, $x^3+3xy-(3x^2+y)\sqrt{y}=a-\sqrt{b}$,

that is, $(x-\sqrt{y})^3=a-\sqrt{b}$;

therefore, $x-\sqrt{y}=\sqrt[3]{a-\sqrt{b}}$. (2)

From (1) $\times$ (2) we have

$x^2-y=\sqrt[3]{a^2-b}=k$, say;

therefore, $y=x^2-k$. Hence from $x^3+3xy=a$ we get

$x^3+3x(x^2-k)=a$, or $4x^3-3kx=a$. (3)

From this point on there is no general solution, though particular examples may be solved by finding a value of x by inspection from Equation (3).

For example, to find cube root of $2+11i$;

$a=2$, $b=-121$, $k=\sqrt[3]{4+121}=5$.

$\therefore$ $4x^3-15x-2=0$. By inspection $x=2$; the other two values of x are -1, $\pm\frac{1}{2}\sqrt{3}$.

Hence, $y=1, -{}^{13}/_{4}-\sqrt{3}, -{}^{13}/_{4}+\sqrt{3}$.

Therefore,

$$\sqrt[3]{2+11i}=2+i,\ -1+\tfrac{1}{2}\sqrt{3}-(\tfrac{1}{2}+\sqrt{3})i,\ -1-\tfrac{1}{2}\sqrt{3}+(\tfrac{1}{2}-\sqrt{3})i.$$

Similarly,

$$\sqrt[3]{2-11i}=2-i,\ -1+\tfrac{1}{2}\sqrt{3}+(\tfrac{1}{2}+\sqrt{3})i,\ -1-\tfrac{1}{2}\sqrt{3}-(\tfrac{1}{2}-\sqrt{3})i.$$

II. *Solution by H. E. Trefethen, Kent's Hill, Me.*

Put $2\pm 11\sqrt{-1}=x\pm iy=\rho(\cos\theta\pm i\sin\theta)$.

Then $\rho^2=x^2+y^2=125$, $\theta=\pm 79°\,41'\,42.6''$, and we have

$$\sqrt[3]{2\pm 11\sqrt{-1}}=\begin{cases}\sqrt{5}(\cos\ 26°\,33'\,54.2''\pm i\sin\ 26°\,33'\,54.2'')\\ \sqrt{5}(\cos 146°\,33'\,54.2''\pm i\sin 146°\,33'\,54.2'')\\ \sqrt{5}(\cos 266°\,33'\,54.2''\pm i\sin 266°\,33'\,54.2'')\end{cases}$$

Hence the six roots are $2\pm\sqrt{-1}$, $-1.866025\pm 1.232051\sqrt{-1}$, and $-0.133975\mp 2.232051\sqrt{-1}$.

III. *Solution by T. M. Blakslee, Ames, Iowa.*

Put $(x+yi)^3=2+11i$.

Let $x+yi=\rho(\cos\theta+i\sin\theta)$,

and $2+11i=\rho'(\cos\theta'+i\sin\theta')$.

Then $\theta'=3\theta$, and $\rho'=\rho^3$.

$\rho' = \sqrt{2^2+11^2} = \sqrt{125}$ $\therefore$ $\rho = \sqrt{5}$, and $x^2+y^2=5$. (1)

Now $\operatorname{Tan}\theta' = \operatorname{Tan} 3\theta = \dfrac{3 \operatorname{Tan}\theta - \operatorname{Tan}^3\theta}{1 - 3\operatorname{Tan}^2\theta}$,

or $\dfrac{11}{2} = \dfrac{3t - t^3}{1 - 3t^2}$, where $t = \dfrac{y}{x}$.

$\therefore$ $2t^3 - 33t^2 - 6t + 11 = 0$. Multiply roots of this eq. by 2, we have $t^3_1 - 33t^2_1 - 12t_1 + 44 = 0$. Since sum of coefficients equals zero

$t_1 = 1$; also $t_1 = 16 \pm 10\sqrt{3}$. $\therefore$ $\dfrac{y}{x} = t = \frac{1}{2}t' = \frac{1}{2}, 8+5\sqrt{3}, 8-5\sqrt{3}$.

Hence $y = \frac{1}{2}x$, $y = (8+5\sqrt{3})x$, $y = (8-5\sqrt{3})x$. (2)

From eqs. (1) and (2) we easily find

$x = 2, -1+\frac{1}{2}\sqrt{3}, -1-\frac{1}{2}\sqrt{3}$,

and $y = \pm 1, \pm(\frac{1}{2}+\sqrt{3}), \pm(\frac{1}{2}-\sqrt{3})$.

Since $\dfrac{y}{x} = \frac{1}{2}$, x and y must have like signs.

Hence $\sqrt[3]{2+11i} = 2+i, -1+\frac{1}{2}\sqrt{3}-(\frac{1}{2}+\sqrt{3})i, -1-\frac{1}{2}\sqrt{3}+(\frac{1}{2}-\sqrt{3})i$.

Similarly

$$\sqrt[3]{2-11i} = 2-i, -1+\tfrac{1}{2}\sqrt{3}+(\tfrac{1}{2}+\sqrt{3})i, -1-\tfrac{1}{2}\sqrt{3}-(\tfrac{1}{2}-\sqrt{3})i.$$

208. ***Proposed by H. E. Trefethen, Kent's Hill, Me.***

The quantity of coal consumed by a steamer varies as the cube of her speed, being 1.5 tons an hour when the speed is 15 miles an hour. If coal costs $4.50 per ton and the other expenses are $4.00 an hour, find the least cost for a voyage of 2,000 miles.

Solution by the Proposer.

I. Let x be the steamer's speed in miles per hour. Then $2000/x =$ number of hours for the voyage, $kx^3 = x^3/2250 =$ number of tons of coal consumed per hour. $(x^3/2250)(2000/x)(9/2) =$ cost of coal in dollars, $4(2000/x) =$ other expenses. Hence the total expenses for the voyage $= 4x^2+8000/x$. Put $2x = z$ and $8000 = a^3$. Then we have $(z^3+2a^3)/z = (z-a)^2(z+2a)/z+3a^2$ to be made a minimum. Since a is positive, the last fraction is positive for all positive values of z. Hence. if $(z-a)^2(z+2a)/z = 0$. we have $z = a = 20$. $x = 10 =$ the speed. and $3a^2 =$ $1200 = least cost for the voyage.

II. With the same notation as above. put $(z^3+2a^3)/z = u =$ min. $z^3 - uz + 2a^3 = 0$. By Cardan's formula, $z = (-a^3+\sqrt{a^6-u^3/27})^{1/3} + (-a^3-\sqrt{a^6-u^3/27})^{1/3}$. From the discussion of Cardan's solution we know that according as $a^6-u^3/27 <, =,$ or > 0, the three roots are real and unequal, two of the roots are equal, or two are imaginary. In the first case there can be no maximum, since u may increase without limit. The second and third cases show that u is a minimum when $a^6-u^3/27=0$, for if smaller the two equal positive values of z become imaginary. Therefore, $u = 3a^2 =$ $1200.

REMARK.—For other methods of solving see p. 598 of the magazine for June, 1909.

A graph of the equation $z^3-uz+2a^3=0$ will aid in making clear the relation of the roots to the minimum. In plotting the graph, make 100, or 200, units on the u axis = one unit on the z axis.

III. *Solution by I. L. Winckler, Cleveland, O; W. B. Borgers, Grand Rapids, Mich.*

As above, $4x^2 + \dfrac{8000}{x}$ = total cost of trip, which must be a minimum.

$\therefore$ the first derivative of this function must equal zero. This gives $8x - \frac{8000}{x^2} = 0$.

$\therefore x=10$. Since the second derivative is positive for $x=10$, $4x^2 + \frac{8000}{x}$ is minimum for this value of x. Hence minimum cost of trip is $1200.

Geometry.

199. *Proposed by I. L. Winckler, Cleveland, O.*

If ABCD is a cyclic quadrilateral, prove that the centers of the circles inscribed in triangles ABC, BCD, CDA, DAB are the vertices of a rectangle.

I. *Solution by H. E. Trefethen, Kent's Hill, Me.*

Bisect the arcs AB, BC, CD, DA at E, F, H, I. Then the arcs $(EF+HI)/2=90°$. $\therefore$EH and FI intersect at right angles.

Let O, P, Q, R be the centers of the circles in order. AF bisects BAC and passes through O, DF bisects BDC and passes through P, etc. $BOF = OAB+OBA = OBC+FBC = OBF$. $\therefore$ $FO=FB=FC$. Likewise, $FP=FC=FO$.

Since $FO=FP$ and FI bisects AFD, OP is perpendicular to FI. Likewise QR is perpendicular to FI, and also PQ, OR to EH. Therefore, OPQR is a rectangle.

II. *Solution by A. W. Rich, Worcester, Mass.*

Let N, O, P, M be the centers of the circles in order. To prove MNOP a rectangle. Take E and F, middle points of arcs CD and BC respectively, and represent arc CD by S, AD by H, AB by K, and BC by R. Draw lines PC and DO. By extending CP and DP to circle, we easily prove

$\angle DPC = \frac{1}{4}(H+K+R)+\frac{1}{2}S$. Also $\angle DOC = \frac{1}{4}(H+K+R)+\frac{1}{2}S$.

$\therefore$ $\angle DOC = \angle DPC$. E is center of a circle passing through C, O, P, D. Likewise F is center of a circle passing through B, N, O, C. Hence we easily find

$\angle COP = \frac{1}{2}(S+H)+\frac{1}{4}(R+K)$,

$\angle CON = \frac{1}{2}(R+K)+\frac{1}{4}(S+H)$.

$\therefore$ $\angle COP + \angle CON = \frac{3}{4}(R+K)+\frac{3}{4}(S+H) = 3\cdot\frac{\pi}{2}$

$\therefore$ $\angle NOP = \frac{\pi}{2}$. Similarly for other angles of MNOP.

Hence MNOP is a rectangle.

209. *Selected.*

A, B, C are three fixed points. Describe a square with one vertex at A, so that the sides opposite to A pass through B and C.

I. *Solution by H. E. Trefethen, Kent's Hill, Me.*

On BC as diameter describe a circle. Let DD be the end points of the diameter perpendicular to BC. Join AD, cutting the circle again in D′. If D and D′ are on opposite sides of BC, AD′ is a diagonal of the required square. The proof is easy.

I. If $A=90°$ (and hence point A on the circumference) and the angles
   (1) $B=C$, there are three solutions;
   (2) B and C unequal, no solution is possible.

II. If $A<90°$ (and hence A outside the circle) and
   (1) neither B nor $C < 45°$, there are two solutions;
   (2) B or $C < 45°$ but neither $> 135°$, one solution;
   (3) either B or $C > 135°$, no solution is possible.

III. If $A > 90°$ (and hence A within the circle) and
(1) neither B nor C $> 45°$, there are two solutions;
(2) either B or C $> 45°$, there is only one solution.

Hence, if the point A is on D, three solutions, one the inscribed square ABDC, the other two equal squares with AB, AC for diagonals and each a quadrant of the circumscribed square; if A is on any other point of the circumference the square reduces to a point; if A is in the vertical angle opposite DBD or DCD, no solution; if A is in the square BDCD or in the vertical angle opposite BDC, two solutions; if A is outside the square BDCD and between two of its opposite sides produced, one solution. If A is on a side of BDCD or a side produced, the number of solutions is the same as for the adjacent region having the larger number, and a side opposite to A passes through both B and C. It will be observed that if A, B, C are collinear and A outside BC, no solution is possible, but if A is between B and C the two required squares are equal, AD being the diagonal of each square when A is the center of BC.

II. *Solution by G. B. M. Zerr, Philadelphia, Pa.*

Let A be the origin of coördinates and let B, C be denoted by (a, b), (c, d) respectively.

Let $y-b=m(x-a)$ be the equation to a line through B.

Then $y-d=-\frac{1}{m}(x-c)$ is the equation to a line through C perpendicular to the first line.

$\frac{b-ma}{\sqrt{1+m^2}}$ = distance from A on line through B

$\frac{dm+c}{\sqrt{1+m^2}}$ = distance from A on line through C

$$\therefore \frac{b-ma}{\sqrt{1+m^2}}=\frac{dm+c}{\sqrt{1+m^2}}$$

Hence $m=\frac{b-c}{a+d}$ and the problem is solved.

Credit for Solutions Received.

Algebra, 196: A. W. Rich. (1)

Algebra, 197: A. W. Rich. (1)

Geometry, 199: G. I. Hopkins, A. W. Rich, H. E. Trefethen. (3)

Algebra, 201: G. E. Butterfield, M. H. Pearson, A. W. Rich, Orville Price. (4)

Algebra, 203: A. W. Rich. (1)

Geometry, 204: M. H. Pearson, A. W. Rich. (2)

Algebra, 207: T. M. Blakslee (four solutions), W. B. Borgers, H. C. Feemster, Richard Morris, A. W. Rich, H. E. Trefethen (two solutions), I. L. Winckler, G. B. M. Zerr. (12)

Algebra, 208: W. B. Borgers, H. C. Feemster, J. M. Kent, A. W. Rich, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (7)

Geometry, 209: L. E. A. Ling, M. H. Pearson, J. M. Townsend, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (6)

Total number of solutions, 37.

PROBLEMS FOR SOLUTION.

Algebra.

217. *Proposed by W. T. Brewer, Quincy, Ill.*

Solve for x, y, and z:

$$8x+8\sqrt{xy}+7y=600 \qquad (1)$$
$$6z+8\sqrt{yz}+7y=520 \qquad (2)$$
$$z+3\sqrt{xz}+3x=210 \qquad (3)$$

218. *Proposed by J. A. Hardin, Ft. Bliss, Tex.*

If $x=7\pm4\sqrt{2}$, and $y=\sqrt{25+\frac{17}{2}\sqrt{2}}\pm\sqrt{25-\frac{17}{2}\sqrt{2}}$,

show that $2y^2=x^2\sqrt{17^2-x^2}$.

Geometry.

219. *Proposed by M. H. Pearson, Montgomery, Ala.*

Construct a triangle, given the altitude, the median, and the angle bisector, all from the same vertex.

220. *Proposed by G. B. M. Zerr, Philadelphia, Pa.*

If c = chord and h = height of a segment of a circle, prove the following approximation, given in works on mensuration:

$$\tfrac{2}{3}ch+h^3/2c = \text{area of segment.}$$

Editorial Note.—We desire to make this department of our Journal invaluable to its readers. To this end contributors and readers are urged to send to the Editor any criticism or suggestion that might be helpful. Have the problems already given been sufficiently practical, real, or interesting? Have they been too abstruse or too simple? Would it be worth while to publish occasionally the solution of some special problem or some short discussion? Should more time be given for solution of problems? Only through the advice and coöperation of those interested in this work can we hope to determine what class of problems will meet the needs and pleasures of the greatest number of our readers. Let us hear from you.

Tungsten filaments are commonly made by mixing the metal in a paste that is then extruded in the form of a filament, after which the paste is expelled and the particles of metal are welded together by an electric current. This complicated method of forming the filaments is due to the fact that tungsten is not sufficiently ductile to be drawn out into fine filaments. An English concern has just discovered a method of producing drawn filaments of tungsten, and the General Electric Company has also just announced the discovery of a method by which tungsten may be rendered sufficiently ductile to permit of its being drawn into fine wires. The drawn tungsten filament is stronger than the filament made by the "sintering" process.

SCIENCE QUESTIONS.

By Franklin T. Jones,
University School, Cleveland, Ohio.

Readers of School Science *are invited to propose questions for solution —scientific or pedagogical—and to answer the questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

Questions and Problems for Solution.

32. *Proposed in the New York Sun.*

What difference would there be in the weight of a perfectly air-tight bird cage, depending on whether the bird were sitting on the perch or flying about?

33. *From an examination paper of Lake View High School, Chicago.*

A bullet, the mass of which is 30 gm., and which is moving with a speed of 3×10^6 cm. per second, strikes a piece of wood and penetrates 10 cm. What is the wood's resistance to penetration? Give answer in joules.

Solutions.

[Problems 21 and 22 were solved by Edmund G. Farrand, Penacook (N. H.) High School. These solutions were received too late to be published in June. Because of their excellence, in particular with respect to form, his solution of Problem 21 is here given exactly as submitted. Clear-cut reasoning of this kind is a thing to be sought in the study of physics.—Ed.]

Physics Example No. 21.

A grocer has a platform balance the ratio of whose arms is 9 to 10. If he sells 20 pounds of merchandise to one man, weighing it on the right-hand pan, and 20 pounds to another, weighing it on the left-hand pan, what per cent does he gain or lose by the two transactions?

Draw a line AB to represent the balance, the arms of which are supported by and rotate about O. Then arm AO : arm BO = 9 : 10 (Hyp.). In the first transaction the merchandise is weighed on the right-hand pan, B, and then it is balanced by 20 pounds of weights at A.

Let x represent the weight at B.

Then, $10x =$ the moments of force at B.

$9\times 20 =$ the moments of force at A.

But the moments of force at B equal those at A (Hyp).

$\therefore\ 10x=9\times20=180.\quad x=18$ lbs.

In the second transaction, let $x' =$ the weight of the merchandise sold. The goods when placed on the pan at A are balanced by 20 lbs. of weights at B.

Then, $9x' =$ the moments of force at A.

$10\times 20 =$ the moments of force at B.

$9x'=10\times20=200.$ (Hyp.) $x'=22.2222+$ lbs.

$x=18.0000$ lbs.

$x'=22.2222$ lbs.

Adding, 40.2222 lbs. = total amount sold.

2×20 lbs. = 40 lbs. = the amount paid for.

40.2222 lbs. — 40 lbs. = .2222 lbs. = amount not paid for.

$\frac{.2222}{40}=.0055=.55\%$ of the total amount sold which is not paid for.

Hence, he loses .55% by the two transactions.

[Additional solutions of Problems 27 to 31 are desired.—Ed.]

The College Entrance Examinations in Physics.

So much has been said and written on this subject that it may justly be regarded as decidedly threadbare. Much of the criticism has been aimed at the questions set by the College Entrance Examination Board and in particular at the supposed methods and standards according to which the papers are marked. As far as the writer knows, no consistent attempt has been made to determine what kind of an answer paper a candidate may be expected to hand in. In the hope of gaining some light on this point it is proposed to print in the succeeding months some sets of college entrance questions. Teachers are requested to have some of their competent pupils write out answers and send them in. It is expected that some of these papers will be published.

The first set of questions given below was submitted in June, 1910, by Sheffield Scientific School. The candidate was supposed to finish in one and a quarter hours and to stand at least 2 on the scale of 4.

Sheffield Scientific School Entrance Examination, June, 1910. Physics.

1. A balloon contains 1,000 cubic meters of a gas whose density is 0.000092 gram per cubic centimeter. Taking the density of air as 0.0013 gram per cubic centimeter, calculate the total weight which the balloon will lift.

2. A 15 gram bullet is shot with a muzzle velocity of 600 meters per second. What average force must have been applied for a distance of 75 centimeters to impart this velocity?

3. What will be the effect on the pitch of a musical string of halving the length? What the effect of doubling the tension? What the effect of doubling the mass per unit length?

4. Explain how a quantity of heat may be measured. State the value of the mechanical equivalent of heat and explain what it means.

5. Show how a simple lens may be used as a magnifier.

6. What are polarization and local action in a voltaic cell? How may each of these effects be prevented?

7. Describe the essential parts of a magneto, a motor, and a dynamo. Explain the purpose which each part serves.

During the manœuvers of the United States Army in Grant Park, on the lake front of Chicago, early in July, the great temporary amphitheater, capable of seating over 40,000 people, was illuminated by means of hundreds of flaming arc lamps, so that the performances could take place during the evening as well as in daylight.

Professor Herbert Brownell has accepted a position in the Teachers' College of the University of Nebraska, and entered upon his new work at the beginning of this school year. He will direct the training of the teachers in the physical sciences to the needs of the secondary schools. He is well fitted for this position, having taught successfully in the Peru State Normal School for seventeen years. Throughout the state he is well known, and from this new field of labor will exert a strong influence on the teaching of the physical sciences in the secondary schools.

REAL APPLIED PROBLEMS IN ALGEBRA AND GEOMETRY.

COMMITTEE ON INVESTIGATION: JAMES F. MILLIS, *Chairman, Francis W. Parker School, Chicago;* JOS. V. COLLINS, *State Normal School, Stevens Point, Wis.;* C. I. PALMER, *Armour Institute of Technology, Chicago;* E. FISKE ALLEN, *Teachers College, New York;* A. A. DODD, *Manual Training High School, Kansas City, Mo.*

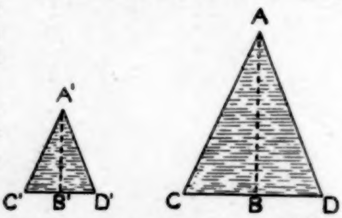
Teachers are urged to use the problems printed in these columns, with a view to determining their adaptability for use in classes in secondary schools.

Copies of the problems printed in these columns up to November, 1909, may be obtained in pamphlet form for class use by writing to Miss Mabel Sykes, Secretary of the Mathematics Section of the Central Association of Science and Mathematics Teachers, Bowen High School, Chicago, or to SCHOOL SCIENCE AND MATHEMATICS.

Problems.

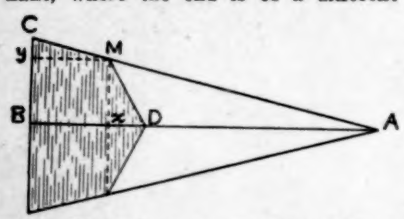
By Miss Marie Gugle, Central High School, Toledo, O.

The following problems are some of the practical problems of geometry encountered by one of the boys of the Central High School, Toledo, O., who does an extensive business in making and selling pennants.



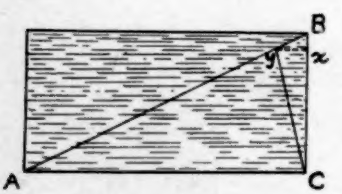
1. A designer, in making a pennant, must make one in the same proportion as a given one, but larger. Find AB, if CD= 36″, A′B′=43″, and C′D′=20″.

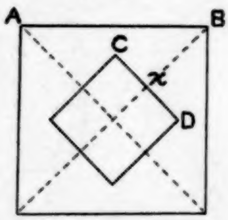
2. In drawing a pattern for a pennant, where the end is of a different color from the point, the designer must find the correct slant in order to have the pieces fit. Given AB=72″, DB=24″, Dx=8″, and CB=18″, to find Cy.



(Draw Mx||CB and My||AB.)

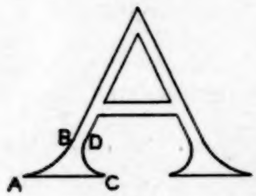
3. To cut from a piece of felt a pennant in the most economical way, how will the designer true the end? If AyC is an isosceles triangle, AC=36″, and BC=17″, find the length of xy.





4. To place a block letter in the center of a square pillow top. How far from each corner will the designer measure to the edge of the letter, if the pillow is 20″ square, and the letter is 10″ square? AB=20″ and CD=10″. Find Bx.

This boy uses his knowledge of geometry in designing the letters for his pennants. The next problem is one illustration.

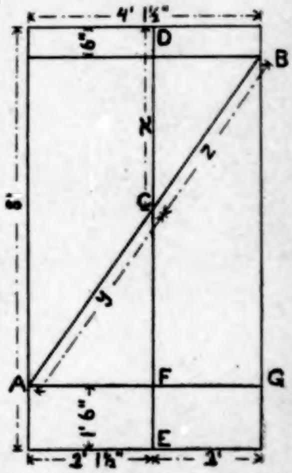


5. Given the points A, B, C, and D, in a letter A; find the centers for constructing the arcs AB and CD.

By Miss Lida C. Martin, High School, Decatur, Ill.

One of the schoolboys who works in a bridge factory had to solve the following problem.

6. The figure is the diagram of a part of the side of a bridge. The point C must be located on AB and on DE, where the holes must be bored to fasten the brace AB to the upright DE. Required to find the lengths of AB, x, y, and z, in order to locate C.



SUGGESTION.—After finding AB, compare triangles ACF and ABG.

By James F. Millis, Francis W. Parker School, Chicago.

In the manufacture of many kinds of articles of common use from sheet metal, such as can lids, pans for cooking, various sorts of metal boxes, etc., first a circular piece of metal, called a "blank," is cut from a flat sheet of it, and then this is pressed into the form of the required article by means of a "die." The diameter of the blank from which any article of given dimensions is to be made must first be computed. In this computation it is assumed that the total area of the finished article is equal to the area of the blank from which it is made. This theoretical diameter of the blank has to be modified by trial, due to the stretching of the metal.

7. The lid for a three pound lard bucket is 5 in. in diameter, and $\frac{1}{2}$ in. deep. Find the diameter of the blank from which it is made.

SUGGESTION.—The total area of the lid is the sum of the area of a circle and the lateral area of a cylinder.

8. A Rumford Baking Powder can lid is 3 in. in diameter and $\frac{7}{8}$ in. deep. Find the diameter of the blank from which it is made.

9. The lid of a Manor House Coffee can is 4 in. in diameter and $\frac{5}{8}$ in. deep. Find the diameter of the blank from which it is made.

10. The lid of a "Shinola" shoe-polish box is $2\frac{5}{8}$ in. in diameter and $\frac{3}{8}$ in. deep. Find the diameter of the blank from which it is made.

11. A biscuit cutter, made from one piece of metal, is $2\frac{1}{2}$ in. in diameter and 1 in. deep. Find the diameter of the blank from which it is made.

12. A stew pan is $6\frac{3}{4}$ in. in diameter at the bottom, $8\frac{3}{4}$ in. in diameter at the top, 3 in. deep, and has a flange at the

top ½ in. wide. Find the diameter of the blank from which it must be made.

SUGGESTION.—The total area of the pan is made up of the circular bottom, the lateral area of a frustum of a cone, and the area of the flange, which is the difference between two circles.

13. A dishpan is 13 in. in diameter at the bottom, 17 in. in diameter at the top, 5½ in. deep, and has a flange at the top ½ in. wide. Find the diameter of the blank from which it must be made.

14. A pie pan is 6¾ in. in diameter at the bottom, 8 in. in diameter at the top, 1 in. deep, and has a flange at the top ½ in. wide. Find the diameter of the blank from which it must be made.

15. A brass bowl is in the form of a hemisphere. Its diameter is 8 in. Find the diameter of the blank from which it is made.

NOTE.—It is interesting to know that door hinges and various kinds of hollow cylindrical metallic tubes are manufactured also from sheet metal, by bending the flat sheet metal into the required forms and dimensions in dies. The principle that the total area of the finished article equals the area of the blank from which it is made applies here also in the computation of the sizes of blanks. Numerous problems of the types that men have to solve may be made up by the teacher from the facts here stated. Thus, measure the sizes of door hinges, and compute the widths of blanks from which they must be made. Compute the dimensions of blanks from which brass curtain rods are made, etc.

All particulars, especially the localities of the discoveries in China, are naturally withheld by the combine. Should the mining of the potassium salts in China be successful, the western part of America will first come in question as a consumer. The salts could be delivered there very cheaply, as the wages of labor in Chinese mines are one tenth of those in German mines, and especially the cheap ocean freight to the west coast of America will be an important factor.

Pan amalgamation tailings usually contain considerable quantities of floured quicksilver and various compounds of mercury resulting from the chemical reactions which take place in the pans. If these tailings be treated with cyanide a considerable percentage of the quicksilver will pass into solution and be precipitated in the zinc boxes. To recover the quicksilver it is first necessary to refine with sulphuric acid, after which the precipitate is retorted when the quicksilver is volatilized and recondensed. In the treatment of the old Comstock tailings by cyaniding the quicksilver recovered formed an important item.

The materials grouped under the head of mineral paints include such iron ores as are ground and used in the manufacture of metallic paints: ochres and other clays rich in iron, which are used for the yellow and brown pigments (ochre, umber, sienna), and which are occasionally roasted to give red pigments; and fine-grained slates and shales of attractive colors, which are ground for use as paints. Many other minerals or mineral products are used in the paint trade, such as graphite, chrome, whiting, talc, asbestos, and barite. Other paints, as venetian red, litharge, white lead, orange mineral, etc., are purely chemical products. Zinc white is made directly from the ore without previous metallurgical processes.

THE BUREAU OF MINES.

The act establishing a Bureau of Mines in the Department of the Interior, approved May 16, 1910, became effective July 1. As originally approved, the law contemplated the transfer of the entire technologic branch of the United States Geological Survey, the mine accident investigations, fuel investigations, structural materials investigations, the entire personnel, property and equipment, to the Bureau of Mines, but the Sundry Civil Appropriation Act, approved June 25, amended the law to such an extent that the structural materials investigations, including the personnel and equipment for these investigations, went to the Bureau of Standards, Department of Commerce and Labor.

Carrying out the spirit and intent of the law so amended, the Secretary of the Interior has transferred to the Bureau of Mines the investigation of mine accidents and fuels, together with the personnel and equipment of these investigations, and has transferred to the Bureau of Standards the structural materials investigations and the employees of the Technologic Branch of the Survey engaged in these investigations. The fully equipped testing station at Pittsburg also goes to the Bureau of Mines.

The work of the Bureau of Mines for the first year will be a continuation and expansion of the work carried on by the Technologic Branch of the Geological Survey. The law in itself provides for a variety of other problems that properly belong to the Bureau of Mines and which should eventually be undertaken, such as methods of mining and metallurgical processes.

The mine accident investigations, which have been transferred from the Geological Survey to the Bureau of Mines, were first authorized in the legislative appropriation act of May 22, 1908, carrying for this purpose an appropriation of $150,000. This was followed by a similar appropriation carried in the act for the sundry civil expenses of the government for 1910. A mine experiment station was established in Pittsburg during 1908, at which, since that time, investigations of explosives, coal gas, dust, electricity and other possible causes of mine explosions have been continually under way.

The fuel investigations under the Geological Survey and which are transferred to the Bureau of Mines have already resulted in a better realization throughout the country as to the value of fuels. One result of this work is that nearly all of the fuel now purchased by the federal government is bought on specifications and subject to test by the fuel division, or purchased after examination made of the coal supplied by the mines from which coal is delivered to the government.

The publications of the Survey relating to mine and fuel investigations, those prepared by the Technologic Branch, will in the future be distributed by the Bureau of Mines. The publications relating to structural materials will continue to be distributed by the Geological Survey.

In order that the work on the Gatun dam of the Panama Canal may be accelerated, labor being continued night and day, this part of the great undertaking has been lighted so that there is no interruption of activities. The illumination is caused by sets of flaming arc lamps strung between the towers of the three cableways which are used to handle the materials of construction. Searchlights are also used to throw pencils of light along work. The lighting is so efficient that the workmen prefer the night shifts to those of daylight when they are obliged to endure the hot rays of a tropical sun.

FROM A LABORATORY NOTEBOOK.

By James Henry Willock,
Troy, New York.

No claim whatever of originality is made for any of these laboratory helps. They were gathered here and there in my reading and gleaned from observation in many laboratories. For this reason acknowledgment is impossible, since by far the most have been simply "passed on." Each has helped me in my science teaching, and the fact that my notebook has been helpful to other young teachers of my acquaintance, leads me to believe these excerpts may be of wider interest.

Stopper for Evaporating Flasks.

To evaporate rapidly and keep dust out of the flask, this device is useful. A two-hole cork or rubber stopper is fitted into the neck of the flask. Through one hole is led a tube connected with a clean air supply. This air passing slowly into the flask drives the steam out through the other hole, into which may be placed an elbow-shaped glass tube.

Absorption Tube.

This is simply a glass tube about 10 cm. long drawn to small diameter at both ends, though left open to permit the passage of gas through it. At either end glass-wool is plugged, the space between is filled with P_2O_5 or $CaCl_2$. Never forget to be uniform in the use of drying agent in a set of apparatus. Use one or the other consistently.

Reducer.

To connect rubber tubing of different diameter, the simple device of a piece of glass tubing drawn out at both ends to small diameter readily solves the difficulty. If rubber tubing be moistened it slips over glass tubing readily.

To Clean Mercury.

First Method.—Filter through a strong paper funnel, having a pinhole at the apex. Mercury filtered in this way is quite free from dust.

Second Method.—Shake up with powdered sugar, then filter as above.

Third or Nitric Acid Method.—Cover the mercury with some dilute nitric acid, to which a little $HgNO_3$ has been added. Stir from time to time. Filter through a separating funnel.

A solution of mercurial nitrate is prepared by dissolving mercury in nitric acid, and is added to the impure mercury which should be contained in a shallow porcelain dish. The action of the liquid is to give at once a perfectly pure appearance to the mercury, but it will be necessary to leave the materials in contact for several weeks, stirring from day to day, before the metallic impurities will entirely leave the metal and enter into solution. When the process is judged complete, the solution should be filtered through a separating funnel.

These methods are sufficient for a time. At last, to obtain mercury quite pure, recourse must be had to re-distillation.

To Clean Glass Perfectly.

Make a strong solution of potassium bichromate. To this about half the quantity of concentrated sulphuric acid is cautiously added. To this mixture add an equal volume of water. Glass slips or cover glasses should

be kept in this a short time, rinsed thoroughly in pure water and dried with a cloth or wash leather.

For ordinary purposes alcohol of usual strength will serve.

To Remove Paint.

Make a mixture of equal parts of alcohol and chloroform. This will also remove wagon or carriage grease.

To Remove a Tenacious Precipitate.

This is readily and simply done by filling the vessel with a solvent and allowing it to stand inverted for a time. Naturally, the more saturated part of the solution sinks to the bottom, allowing fresh solvent to act. This will save much time and labor.

Electric Amalgam.

This is made by placing one part of tin and two parts of zinc in a crucible, just fusing, and then adding six to eight parts of mercury. Stir while cooling, and then reduce mass to powder. It may be mixed with lard and applied to the rubbers, or the rubbers may be smeared with lard and the amalgam sprinkled over it.

Dissecting Salt.

Pulverize separately, then intimately mix, equal parts of white arsenic and alum. Label POISON.

Wax for Glass Joints.

Three parts of vaseline to one part of beeswax. Melt separately, then melt together.

Stop-cock Grease.

Four parts vaseline, one part rosin, one part paraffin. Melt together thoroughly.

Formula for Preparing Alcoholic Solution of Desired Strength.

Where x=volume required,

a=% of solution required,

$x=\frac{ac}{b}$ b=% of solution used,

c=volume stock solution used.

Carbolized Water.

This is simply a 2% solution of carbolic acid in water.

When boring rubber stoppers, wet the cork borer with ammonia.

Vanadium salts make good indelible ink.

To make an air-tight joint between glass and rubber, smear glass with castor oil, which will not act on the rubber, and make fast with a rubber band.

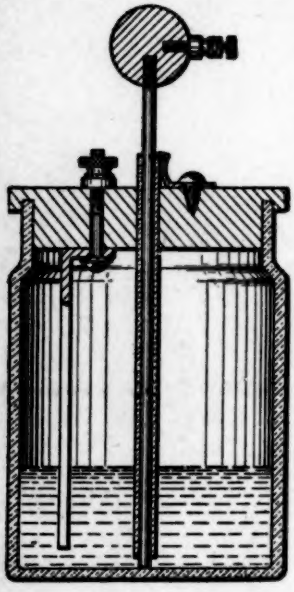
Use acetone instead of alcohol for drying apparatus; the advantages are cheapness and efficiency.

CONSTRUCTION OF A SIMPLE ELECTROLYTIC INTERRUPTER.[1]

BY GEORGE F. WORTS.

The electrolytic current interrupter described here may be used in place of the troublesome vibrator on spark coils. It is to be operated on 50 to 220 volts direct or alternating current. The interruptions obtained with this type of interrupter are very high, being in the neighborhood of 1,000 per second.

The electrolyte and electrodes are contained in a wet battery jar. A wood plug should be turned to fit tightly in the top of the jar, and boiled thoroughly in paraffin to protect it from the acid fumes. A glass tube 6 inches long with an internal diameter of ⅛ inch should be procured, and a hole slightly larger than the external diameter of the tube bored through the center of the wood cover. The tube is held in position by a heavy brass spring pressing against it. For the anode a ⅛-inch round brass rod should be straightened, so as to slide very easily through the glass tube. One end of the rod should be squared off, and the other end threaded and a tapped brass ball fitted to it. This weight, by gravitation, feeds the rod into the solution as it is used. One side of the ball should be tapped and fitted with a binding post for connecting purposes. The cathode consists of a lead strip, 6 by 1 by ⅛ inch, suspended in the solution from a machine screw, the threaded end of which terminates in a binding post for connections. To assemble: Fill the jar a third full with a 10 per cent solution of sulphuric or nitric acid; place the wood cover on firmly, lower the glass tube through the hole till it is ⅛ inch from the bottom of the jar, and tighten the spring against it. Then put the rod through the glass tube till it is resting on the bottom of the jar. In use, when the circuit through the apparatus is closed, non-conducting bubbles form and break on the anode, thus interrupting the current. If the interrupter is used on alternating current, the anode will wear down quickly. Connections using alternating current are identically the same as direct, but without regard to polarity, as alternating current constantly reverses poles. If intended for continuous work, the electrolyte should be cooled by running water through a coiled glass tube in the bottom of the jar. This interrupter will successfully operate coils from the small sizes up to the 10-inch size, and is especially desirable in wireless telegraphic transmission, as it aids materially in the production of a penetrating, high-frequency wave.

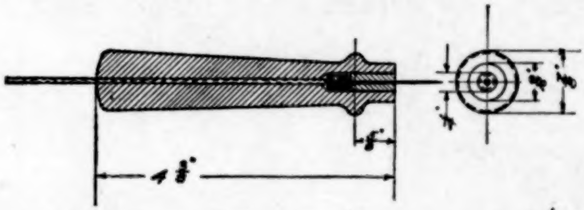


[1]Scientific American.

DEVICE FOR TESTING ELECTRIC WIRING.[1]

By Howard M. Nichols.

In testing electric wiring for open circuits, grounds, or short circuits, it is often necessary to skin the insulation from the wires under test, in a number of places, so as to connect them to a magneto or other testing device. The accompanying illustration shows a device which does away with this necessity; for it contains a sharp needle point, which can be



easily pushed through the insulation until it makes a good electrical contact with the wire within. The device is made out of a hard wood handle, bored throughout its whole length to the diameter of flexible lamp cord. The small end is then counterbored to a larger diameter and a plug is made that will drive tightly into the counterbore. The next step is to procure a large-sized sewing needle, which is driven through the plug as shown in the sketch. The eye end of the needle is soldered to a length of lamp cord which is passed through the handle. The plug is then driven into place and the testing handle is ready for use.

[1]Scientific American.

GEISSLER TUBES FROM ELECTRIC LIGHT BULBS.[1]

By James Bailey.

Many people have wished to perform experiments with Geissler tubes, but owing to their high cost have not been able to do so.

By the following simple and inexpensive method anyone who possesses a one-inch, or larger, induction coil can make a very good substitute for a Geissler tube from any of the standard electric light bulbs. Burned-out lamps or lamps in which the filaments are broken give the best results, and can be had for next to nothing. The effect is much better if the filament is broken into fine pieces, as it then does not interfere with the discharge in the bulb. Metal filaments can easily be broken by striking the lamp with the hand, but in carbon lamps the filament is sometimes so tough that it cannot be broken without injuring the bulb.

First make a cone-shaped lump of sealing-wax with a wire or a pin through the center, as shown in Fig. 1. Then heat the bulb enough to make the wax stick to it, and press the cone against the bulb, holding it there until the wax has set. The end of the wire will now press against the glass, as shown in Fig. 11. Great care should be taken to get the wire and glass stuck in the wax perfectly air tight, as the permanence of the completed tube depends entirely upon this. When the wax is cool, connect the wire to one terminal of the coil and the socket end to the other terminal. The current will puncture the glass directly in front of

[1]Scientific American.

the wire and a light bluish glow will fill the bulb. If the wax was stuck to the glass and wire perfectly air tight, no air can leak in through the fine hole made by the spark, and the vacuum will not be destroyed. If air does leak in, the whitish blue color will gradually change to a pinkish glow, and when just the right amount has leaked in, striations will occur as in real Geissler tubes.

Allowing just the right amount of air to leak in is a rather difficult process, but it can be done most simply as follows:

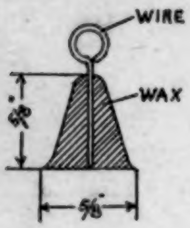


FIG. I

FIG. II

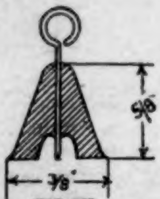


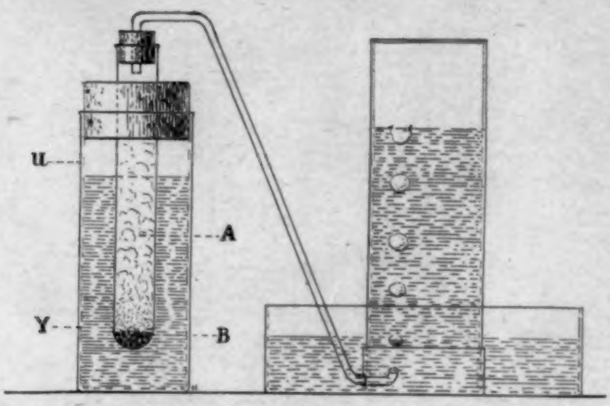
FIG III

Instead of making a wax cone as in Fig. 1, make a bell-shaped piece, as in Fig. 3. With a sharp file nick the bulb where the end of the wire will come. The purpose of this nick is to help the spark puncture the glass. It should not be made deep enough to allow any air to enter the bulb. Next stick the wax bell on the bulb so that the end of the wire rests in the nick. Connect to the coil as before, and turn on the current. The spark will jump through the glass and whatever air is in the bell will leak into the bulb. By varying the size of the bell different colored glows may be obtained. The wax bell in Fig. 3 shows about the size for the best results with 16-candle-power lamps. Different lamps give different results, so that the exact size of the bell cannot be determined, and striations are more or less a matter of luck. Almost every bulb made as above will show beautiful color effects, each different from the other, and the results are well worth the trouble.

Among the many helpful publications issued by the Carnegie Foundation for the Advancement of Teaching is Bulletin No. 3 on "Standard Forms for Financial Reports of Colleges, Universities, and Technical Schools." The suggestions should be followed by those institutions which are tax-supported and are therefore obliged to submit annually reports of their financial condition. If these reports could be gotten out in such a form that the tax-paying constituency would be interested in reading them, it would work toward strengthening these same institutions in the minds of the public. Boards of Education in some of our cities can profitably take good lessons from this splendid bulletin in presenting their reports to the citizens whom they represent. The bulletin cannot help but assist in making educational institutions more business-like in their management.

SAFE PREPARATION OF HYDROGEN.

The teacher of practical chemistry has usually a considerable amount of anxiety while young pupils, especially in large classes, are preparing and experimenting with hydrogen. The following method of obtaining the gas, though it can lay no claim to originality except in its application to class teaching, is very convenient, and, so far as I am aware, is not well known. There is no danger of an explosion, and even the youngest and most careless pupils can be left without supervision.

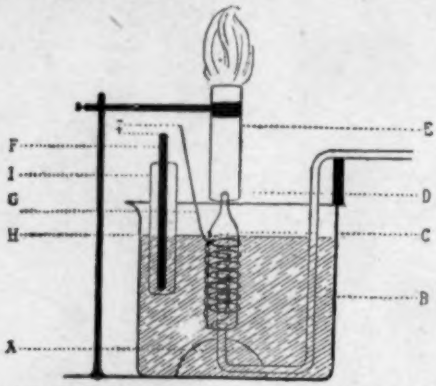


The hydrogen generator, A, consists of a piece of glass tubing about 14 cm. in length and 2.5 cm. in diameter, and is drawn out at one end until about 0.5 cm. in diameter. This end is plugged loosely with glass wool, and the tube is filled with granulated zinc. The glass cylinder, B, is provided with a cork through which the tube A passes, and is half filled with dilute sulphuric acid. The apparatus is fitted up as shown in the diagram. The hydrogen is evolved steadily, and the supply of gas can be regulated by raising or lowering the tube A, which will remain in any position, provided it fits tightly in the cork. The whole apparatus is made easily, stands firmly, and is very portable. A supply of gas is obtained at once by simply lowering the tube containing the zinc into the acid. Other gases can be prepared very conveniently in the laboratory in this manner—*e. g.*, nitric oxide, replacing the zinc with copper turnings and the sulphuric acid with nitric acid of medium strength.—*School World.*

Explosions are often caused in flour mills and breweries by nails or other iron particles that find their way in the grain, and which when they strike the steel rolls of the mills produce sparks and ignite the finely pulverized material about them. Recently a large malting concern that had been troubled by many such explosions installed a set of electro-magnets over which the grain is passed before being prepared for shipment to the breweries. All iron particles in the grain are thus picked up by the magnets and 800 to 1,000 bushels of grain are cleaned per hour. When the magnets have collected a large amount of metal, they are swung to one side, de-energized, and swept clean of any particles adhering to them by residual magnetism. Since the installation of these magnets there have been no explosions in the mills.

CONTINUOUS COLORED FLAMES.

In spectroscopic and other researches it is often necessary to employ a light of definite color for considerable periods of time. A flame of pure and intense color can be maintained for hours by means of the simple apparatus here described and illustrated, which can be made of materials to be found in every laboratory.



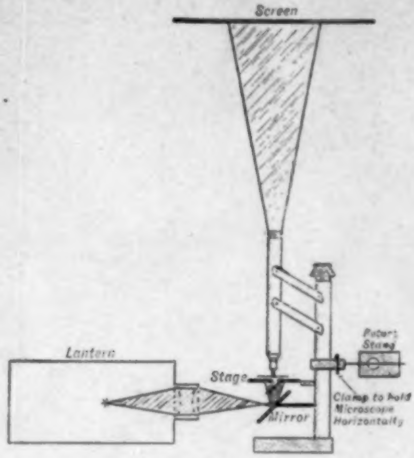
APPARATUS FOR THE PRODUCTION OF COLORED FLAMES.

To the gas pipe is connected a bent glass tube (B) which passes over the rim of a beaker of Bohemian glass, follows the inner surface of the beaker to the center of the bottom, and thence rises vertically, nearly to the top of the vessel. The end of this tube is surrounded by a larger glass tube, the upper end of which is tapered and enters, above the rim of the beaker, the bottom of a wide porcelain tube, which serves as a Bunsen burner. A wire, wound in a helix around the small glass tube, and then around the larger tube which surrounds it, forms the cathode of a galvanic battery, of which a rod of carbon (F) forms the anode. The beaker is filled very nearly to the top of the small glass tube, with a solution of the salt from which the coloration of the flame is to be obtained. The gas is then turned on and the mixture of gas and air is ignited at the top of the porcelain burner. The hydrogen disengaged at the cathode rises into the burner, carrying with it minute drops of the solution which give the colorless Bunsen flame an intense and uniform color.—*Scientific American Supplement.*

MICROSCOPIC PROJECTIONS.

The accompanying diagram shows the arrangement for obtaining a microscopic projection easily seen and studied by a fairly large class. The main parts are a lantern of the oxy-hydrogen type and a simple school microscope. The lantern is used with the condenser alone, the other lenses being removed. The microscope is held horizontally by means of a tripod stand and clamp so that the mirror of the microscope is just beyond the focus of the rays coming from the lantern. The light is reflected on to the slide on the stage, and, passing through the microscope, throws a greatly magnified image on to a screen which is placed several feet away from the eye-piece of the microscope. The image is focused on to the screen by the use of the focusing screw on the microscope.

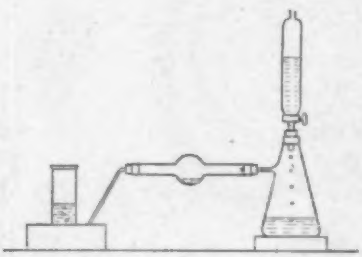
In schools where the number of microscopes is limited the arrangement will be found of great advantage, as the microscopic structure of any section, etc., can be shown to the whole class at one time, and careful drawings can be made easily.



Where a large number of microscopes are available a typical section, etc., can be shown on the screen, and the main points to be observed pointed out before the pupils are asked to use the microscope for independent observation, thus overcoming the common difficulty of their being unable to recognize the main points when examining the section. If the screen be made of fine tissue paper the whole image can be traced on it, and in this way a large and accurate representation obtained for future use. This drawing is far in advance of the usual diagram put before the pupil.—*School World.*

THE ACTION OF BURNING PHOSPHORUS UPON AIR.

While studying this subject, the following experiment was suggested by one of my pupils (first year). It may possibly be as new to some science teachers as to myself. By means of the apparatus shown, a stream of air is passed over gently heated phosphorus in the tube, so as to keep it just burning without producing too much heat. The volume of air passed through and the volume of nitrogen collected can be easily measured. The results are quite accurate enough to give a fair idea of the fraction of air consumed (which was the object of the experiment), and all difficulty arising from expansion of air is avoided.—*School World.*



A series of tests was recently conducted for the Board of Education of Newark to determine the best form of lighting for schoolrooms. The rooms in which the experiments were tried measured 22 by 34 feet and were 12 feet high. Three systems were tried, consisting of twenty-two 16-candle-power lamps, five 75-candle-power graphitized filament lamps, and five 100-watt tungsten lamps with glass reflectors and frosted tips. The tungsten lamps were the most economical and gave by far the best light at each desk, as was determined by illuminometer readings. A similar investigation has been made in Boston, where it was suggested that the room be lighted by lamps placed along the side walls just under the ceiling in boxes with prismatic glass buttons which would cast the rays into the room at the desired angle.

ARTICLES IN CURRENT MAGAZINES.

American Forestry for June: "A Forward Step in Forest Conservation," William L. Hall (Illustrated); "Forty-five Americans in the Forests of Germany," Howard R. Krinbill; "The Mission of Eucalyptus," Florence Lillian Pierce (Illustrated); "Woman's Work for Conservation," Mrs. Lydia Adams-Williams; "Some Observations on Forests and Water-flow," J. T. Rothrock; "The Histology of Resin Canals in White Fir," C. D. Mell (with diagrams.) For July: "The New Forest Products Laboratory," Edwin A. Start (illustrations from photographs); "The Work of the Government in Forest Products," Henry S. Graves; "The Paper and Pulp Industry and Conservation," B. R. Goggins; "Tennessee River Improvement and Sedimentation," L. C. Glenn. For August: "Planting Forests in Kentucky," J. B. Atkinson; "Americans and American Trees in Germany"—a series of pictures, Howard R. Krinbill; "The Weeks Bill in Congress"; "Agencies for the Restoration and Conservation of Forests," S. B. Elliott; "Notes on the Identification of a Tropical Wood," C. D. Mell.

Auk, The, for July: "Migration of the Pacific Plover to and from the Hawaiian Islands," H. W. Henshaw; "Notes on the Autumn Migration of the Canada Goose in Eastern Massachusetts," J. C. Phillips; "The Black-Throated Green Warbler," Cordelia J. Stanwood; "Notes on the Summer Birds of Kentucky and Tennessee," Arthur H. Howell; "Bird Photographing in the Carolinas," B. S. Bowdish; "Resurrection of the Red-Legged Black Duck," William Brewster.

Condor, The, for July-August: "Some Colorado Night Heron Notes" (with nine photos by the author), Robert B. Rockwell; "Nesting of the Spotted Owl in Northeastern Los Angeles County, California," Lawrence Peyton; "Notes on the Rufous-crowned Sparrow" (with one photo by W. Otto Emerson), J. R. Pemberton; "The Anna Hummingbird," J. H. Bowles; "Late Spring in Lake Valley" (with two photos), Milton S. Ray.

Mining Science for June 2: "The Lander Mining District, Nevada," Al. H. Martin. For July 28: "Possibilities of the Oxy-Acetylene Welding Process," C. M. Smyth. For August 4: "Metals in the Rain of Star Dust," Charles R. Keyes.

Photo-Era for July: "The Cost of Photography as a Hobby," C. H. Claudy; "When the Sun in Low" (I. Seascapes), William S. Davis; "Simultaneous Printing and Developing of Enlargements," F. J. Mortimer; "The Portrait-Work of Furley Lewis," A. H. Blake. For August: "Weak Links in the Chain," C. H. Claudy; "The Pictorial Attractions of Boston," Wilfred A. French; "Only a Photograph," Geo. G. Rockwood.

Physical Review for June: "Studies in Thermo-Luminescence. III. The Distribution of Energy in the Luminescence Spectrum of Sidot Blende," C. A. Pierce; "On the Extra Transmission of Electric Waves," F. C. Blake; "Magnetostriction in Iron-Carbon Alloys," Herbert G. Dorsey; "The Point Discharge in Air for Pressures Greater than Atmospheric," O. Amsden Gage; "The Physical Properties of Binary Liquid Mixtures," J. C. Hubbard; "On Entropy," W. S. Franklin; "The Effect of Pressure on the Aluminum Rectifier," A. P. Carman and G. J. Balzer. For July: "A Method for Measuring Ellipticity and the Determination of the Optical Constants of Metals," A. Q. Tool; "The Second Postulate of Relativity," Richard C. Tolman; "An Experimental Determination of the Charge of an Electron by the Cloud Method," L. Begeman; "Heat Transfer Due to Steam Condensation," S. Leroy Brown; "The Reflecting Power of Ice in the Extreme Infra-red Spectrum," A. Trowbridge and B. J. Spence; "An Investigation of Non-Vibratory Types of Frequency Meters," C. E. Hiatt; "A Laboratory Arc Lamp," Edwin F. Northrup; Presidential Address, "The Debt of Physics to Metaphysics," Henry Crew.

Plant World for June: "The Coastal Deserts of Jamaica," Forrest Shreve; "A Comparison Between Two Mountain Sides," J. C. Blumer; "Two New Zealand Botanical Reports," S. B. Parish; "The Starch Content of Leaves Dropped in Autumn," L. L. Harter.

Popular Astronomy for June-July: "On the Physical Cause Which Has Produced the Small Obliquity of the Planet Jupiter," T. J. J. See; "Accurate Measurements of Photographs," Edward C. Pickering; "Quality of Light," Paul F. Bauder; "Sketch of the Career of Professor C. W. Pritchett, Plate XIII," T. J. J. See; "Graphic Solar Discs," W. F. Carothers; "New Double Stars," E. D. Roe, Jr.; "The Story of Halley and His Comet, Plates XIV and XV," Ralph E. Wilson. For August-September: "Spectroscopic and Visual Binaries," Frank Schlesinger and Robert H. Baker; "Are Space and Time Really Infinite," William H. Pickering; "Meteors from Halley's Comet on May 6," E. W. Abell.

Popular Science Monthly for June: "Scientific Work of the Department of Agriculture," Dr. W. J. McGee; "Instinct and Intelligence in Birds," Professor Francis H. Herrick; "Scenery Soil and Atmosphere," Professor Albert Perry Brigham. For July: "A Naturalist in the Straits of Magellan," Dr. Charles Haskins Townsend; "The Future of the Human Race," Professor T. D. A. Cockerell; "Middle and Distance Running," Charles E. Hammett; "The Symbolism of Dreams," Dr. Havelock Ellis; "The Nature of Disease and of its Cure," Dr. James Frederick Rogers. For August: "The Past and Present Status of the Ether," Professor Arthur Gordon Webster; "Physiologic Light," F. Alex. McDermott; "Instinct and Intelligence in Birds," Professor Francis H. Herrick; The Paleontologic Record: "Anatomy and Physiology in Invertebrate Extinct Organisms," Rudolf Ruedemann; "Contributions to Morphology from Paleontology," Professor William Bullock Clark; "Relation of Embryology and Vertebrate Paleontology," Professor Richard Swan Lull; "Observations on the Earthquake of May 26, 1909," Professor J. A. Udden; "The Methods and Uses of a Research Museum," Joseph Grinnell; "The Effects of Smoking on College Students," Dr. George L. Meylan; "The Danger of Unskill," Walter G. Beach; "Bacteriology and Parasitology in Relation to Avian Diseases," Dr. George Edward Gage; "The Role of Selection in Plant Breeding," Professor Edward M. East.

Psychological Clinic for May: "The Nervous Disorders of School Children," Walter S. Cornell, M.D.; "A Further Study of Retardation in Illinois," G. W. Gayler; "Physiological Age as a Basis for the Classification of Pupils Entering High Schools—relation of Pubescence to Height," Wilfred L. Foster, M.D. For June: "Medical and Dental Inspection in the Cleveland Schools," J. E. Wallace Wallin, Ph.D.; "A Moral Imbecile or a Bad Boy: Which?" Arthur Holmes, Ph.D.

School Review for June: "The Achievements and Shortcomings of the American College," J. McKeen Cattell; "The Achievements and Shortcomings of the American College," David Snedden; "The Fifth Annual International Esperanto Congress," Herbert Harris and Edwin C. Reed; Educational Progress in 1909," James E. Downey.

Science for June 10: "Practical Science," John M. Coulter; "Botany in its Relations to Agricultural Advancement," C. V. Pifer.

Scientific American for July 16: "Radium Collector for Electricity"; "Photographing Projectiles in Flight." For 23: "A Dinosaur Skeleton With Skin Three Million Years Old," Barnum Brown.

Scientific American Supplement for July 16: "A New System of Wireless Telegraphy"; "The Light of the Firefly," H. E. Ives and W. W. Coblentz. For July 23: "Making Sapphires in the Laboratory," A. A. Heller.

Sibley Journal of Engineering for June: "Rating of Stationary Gas Engines," G. W. Lewis and A. G. Kessler; "Modern Problems in Transformer Design," Louis F. Blume; "Feed Water Heating in a Cotton Mill," Harvey B. Mann; "Electrical Characteristics of Carbon Brushes," J. L. Smith.

Technical World Magazine for July: "What Is the Firefly's Secret?" Robert A. Sanborn; "Building a Town a Day," James Oliver Curwood; "Bargain in College Education," Ralph Bergengren; "The Truth About Concrete," Benjamin Brooks; "Refilling the Breadbasket," Harry F. Kohr; "World's Greatest Seaport," Charles Frederick Carter; "How Your Fishing Rod Is Made," Harry H. Dunn; "To Cut Scotland in Two," Cecil Bembridge; "Poisons as Servants of Man," J. Emile Blomen.

Terrestrial Magnetism and Atmospheric Electricity for June: "The Complete Magnetic Results of the First Cruise of the 'Carnegie,'" L. A. Bauer and W. J. Peters; "Atmospheric Electricity Observations on the First Cruise of the 'Carnegie,'" Edward Kidson; "Times of Abruptly Beginning Magnetic Disturbances, as Recorded at the Coast and Geodetic Survey Magnetic Observations," R. L. Faris; "The Physical Theory of the Earth's Magnetic and Electric Phenomena," L. A. Bauer.

Zeitschrift für den Physikalischen und Chemischen Unterricht for May: K. Noack, "Hilfsmittel für Schülerübungen zur Mechanik fester Körper;" W. Stephan, "Bestimmung des elektrochemischen Aequivalents von Metallen ohne Wägung;" P. Ludewig, "Uber die Verwendung des Galvanometers zum Nachweis geringer Wechselströme niedriger Frequenz;" Kirstine Meyer, "Von welchen Voraussetzungen muss man ausgehen, um den Begriff 'Temperatur' definieren zu können;" T. Wulf, "Zur Definition der elektrostatischen Kapazität;" M. Salzer, "Zwei astronomische Schülerübungen;" K. Noack, "Masse und Trägheitsmoment;" R. Ullrich, "Messende Versuche über die Grösse des Luftdrucks;" A. Witting, "Bestimmung des Brechungsquotienten von Flüssigkeiten;" E. Rupp und G. Rotter, "Uber einen kleinen elektrischen Ofen für Demonstrationszwecke."

MATHEMATICS SECTION OF THE ASSOCIATION OF KENTUCKY COLLEGES.

The second annual meeting of the Mathematics Section of the Association of Kentucky Colleges was held April 30 at Georgetown College, with the following program:

Theory of Exponents: When and How to Present the Subject, E. L. Reese, State University; The Student's Aim in the Preparation of His Work, W. H. Garnett, Kentucky Wesleyan; Review of David Eugene Smith's "The History of Modern Mathematics," Josephine A. Robinson, Berea College; Should the Colleges of the Association Attempt to Coördinate Their Mathematics Courses? If so, to What Extent, and How Should It Be Done? J. Morton Davis, State University; C. G. Crooks, Central University; Should Logarithms Be Taught in Secondary Schools? Mamie E. Schmidt, Lexington High School; Report of the Progress of the Proposed Book on Secondary Mathematics, A. L. Rhoton, Georgetown College; The Mathematics Course Recommended to Kentucky High Schools at Our December Conference: Its Relation to the Requirements of the Carnegie Foundation: How to Secure Its Adoption by the State Board and the High Schools, Informal Discussion.

J. Morton Davis of State University was elected president of the section for the coming year, and Josephine A. Robinson of Berea College was re-elected secretary. It was regretted that Professor Crooks was detained at home by illness in his family.

Besides those on the program there were present Mr. Downing of State University, the venerable Professor Rucker of Georgetown College, and Miss LeSturgeon of the same institution.

The papers presented were of interest and of practical value. It is the plan of the section to discuss not only questions which deal with methods and courses of study, but also to study topics for the development of its members.

Professor Davis's paper called forth animated discussion in regard to accredited schools, how they shall be ascertained, and how their work shall be kept up to standard. It also developed a discussion of uniform entrance examinations and of tests of efficiency of students after admission. This topic will be resumed at the informal meeting of the section at Lexington next December. At the close of the session the members of the section and a few guests were entertained at an elegant and substantial luncheon at the Lancaster Hotel. JOSEPHINE A. ROBINSON.

EASTERN ASSOCIATION OF PHYSICS TEACHERS.

The fifty-sixth meeting of this organization was held at Providence, Saturday, May 21. The morning session was held in the Technical High School. After the meeting had been called to order by the president, Frank M. Greenlaw, the secretary read the list of standing committees for the coming year. From the Committee on New Apparatus George A. Cowen described a new Falling Body Apparatus and also a cheap form of a wooden beam balance which in the hands of the average secondary school pupil is capable of doing just as accurate work as the more expensive balances. Mr. C. H. Andrews described the new form of Stoelting's universal laboratory weights as well as the Gaetner new high school galvanometer of the D'Arsonval type and a dynamo analysis apparatus by the same maker. Mr. C. M. Hall described two simple forms of photometers, one of the Rumford, the other of the Bunsen type. The Association voted to assist the

science department of the National Educational Association in any way they should desire.

The address of the morning was given by Mr. John L. Alger, Principal of Rhode Island State Normal School, on "Physics as a Part of the Grade Teacher's Equipment." This was a splendid paper, one which ought to be read by all seventh and eighth grade science teachers as well as secondary teachers of science. It is hoped that this paper will be published in SCHOOL SCIENCE AND MATHEMATICS. The paper was ably discussed by several members after its reading.

The afternoon session was held at Wilson Hall, Brown University, the address being given by Professor Carl Barus on "Interferometry and a New Interferometer." This was a very helpful and interesting paper.

The meeting closed with an inspection of the laboratories. S.

WEBSTER'S NEW INTERNATIONAL DICTIONARY.

There is nothing better in the dictionary line than this work. People who make daily use of books of this character know this to be a fact. The Webster, published by the Merriam Company, has never been found wanting. How good it is when looking for information such as should be found in a dictionary to find what one wants on the first trial. One is never disappointed when the Merriam Webster is used. This book is an absolutely new creation and contains everything that should be found in a dictionary. It is a book which is easy to use. A copy should be in use in every school room of the country, as well as in every home and library. The dictionary is consulted, perhaps, more frequently to ascertain the correct pronunciation of a word than for any other purpose. The pronunciations of words in this work are absolutely correct. It is therefore the greatest agent in the English language which is working for the correct pronunciation of words, thus obliterating provincialisms and making our spoken English as pure in one part of the country as another. This work is encyclopedic in character, containing all of the words in our language, giving correct and exact information about them. Wherever one turns he finds splendid condensed treatises, or tables, or illustrations. One cannot use the New International without being impressed by the range and completeness of the information furnished.

BOOK REVIEW.

Elements of Algebra, by Arthur Schultze, Ph.D., Assistant Professor of Mathematics, University of New York. Pp. 305. Price, $.85. 1910. The Macmillan Company.

In this book an attempt has been made to shorten the usual course in algebra, and still give the pupils the requisite mastery of the essentials of the subject. To accomplish this purpose, (1) all unnecessary "cases" are omitted; (2) all parts of the theory which are beyond the comprehension of the pupil or which are logically unsound are omitted; (3) the exercises are somewhat simple; and (4) topics of practical importance, as quadratic equations and graphs are placed early in the course.

There is little in this book to distinguish it from the older type of text-book except the graphical work. This, however, is all included in one chapter near the middle of the book. The author considers that the field of genuine applications of elementary algebra suitable for high school pupils is rather small; hence, there is not a large number of problems of that type. It is undoubtedly a clear and logical presentation of the subject and will be approved by the teachers who have the same point of view as the author. H. E. C.

SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the February, June and October issues of this journal the name and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Officers for the Minneapolis Meeting: *President*, Albert A. Michelson, University of Chicago, Chicago, Ill.; *Vice-Presidents*—A, Mathematics and Astronomy—Eliakim H. Moore, University of Chicago, Chicago, Ill.; B, Physics—Edward B. Rosa, Bureau of Standards, Washington, D. C.; C, Chemistry—George B. Frankforter, University of Minnesota, Minneapolis, Minn.; D, Mechanical Science and Engineering—A. Lawrence Rotch, Blue Hill Meteorological Observatory, Hyde Park, Mass.; E, Geology and Geography—John M. Clarke, New York State Geologist, Albany, N. Y.; F, Zoölogy—Jacob Reighard, University of Michigan, Ann Arbor, Mich.; G, Botany—Robert A. Harper, University of Wisconsin, Madison, Wis.; H, Anthropology and Psychology—Roland B. Dixon, Harvard University, Cambridge, Mass.; I, Social and Economic Science—Hon. Theodore E. Burton, Cleveland, Ohio; K, Physiology and Experimental Medicine—Frederick G. Novy, University of Michigan, Ann Arbor, Mich.; L, Education—A. Ross Hill, University of Missouri, Columbia, Mo. *Permanent Secretary*, L. O. Howard, Smithsonian Institution, Washington, D. C.; *General Secretary*, Frederic E. Clements, University of Minnesota, Minneapolis, Minn.; *Secretary of the Council*, John Zeleny, University of Minnesota, Minneapolis, Minn.; *Secretaries of the Sections*—A, Mathematics and Astronomy—George A. Miller, University of Illinois, Urbana, Ill.; B, Physics—A. D. Cole, Ohio State University, Columbus, Ohio; C, Chemistry—C. H. Herty, University of North Carolina, Chapel Hill, N. C.; D, Mechanical Science and Engineering—G. W. Bissell, Michigan Agricultural College, East Lansing, Mich.; E, Geology and Geography—F. P. Gulliver, Norwich, Conn.; F, Zoölogy—Maurice A. Bigelow, Columbia University, New York, N. Y.; G, Botany—H. C. Cowles, University of Chicago, Chicago, Ill.; H, Anthropology and Psychology—George Grant MacCurdy, Yale University, New Haven, Conn.; I, Social and Economic Science—Fred C. Croxton, 1429 New York Avenue, Washington, D. C.; K, Physiology and Experimental Medicine—George T. Kemp, Hotel Beardsley, Champaign, Ill.; L, Education—C. R. Mann, University of Chicago, Chicago, Ill. *Treasurer*, R. S. Woodward, Carnegie Institution, Washington, D. C.; *Assistant to Permanent Secretary*, F. S. Hazard, Office of the A. A. A. S., Smithsonian Institution, Washington, D. C.

AMERICAN FEDERATION OF TEACHERS OF THE MATHEMATICAL AND NATURAL SCIENCES.

Executive Committee: Chairman, C. R. Mann, University of Chicago; *Secretary*, Eugene R. Smith, Polytechnic Preparatory School, Brooklyn; J. T. Rorer, Central High School, Philadelphia; Wilhelm Segerblom, Phillips Exeter Academy, Exeter, N. H.; I. N. Mitchell, State Normal School, Milwaukee.

AMERICAN MATHEMATICAL SOCIETY.

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ASSOCIATION OF AMERICAN GEOGRAPHERS.

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ASSOCIATION OF BIOLOGY TEACHERS OF NEW YORK.

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President, Frank E. Miller, Westerville, Otterbein University; *Vice-President*, William T. Heilman, Columbus, North High School; *Secretary-Treasurer*, Charles T. Prose, Zanesville, High School; *Assistant Secretary*, Harriet E. Glazier, Oxford, Western College for Women.

ASSOCIATION OF MATHEMATICAL TEACHERS IN NEW ENGLAND—COUNCIL FOR 1910.

President, Charles A. Hobbs, Watertown, Mass; *Vice-President*, Professor William R. Ransom, Tufts College, Mass.; *Secretary*, George W. Evans, Charlestown High School, Boston, Mass.; *Treasurer*, Frank P. Morse, Revere High School, Revere, Mass.; Professor Dana P. Bartlett, Massachusetts Institute of Technology, Boston; Miss Gertrude E. Bigelow, Boston Normal School, Boston; Professor Edward V. Huntington, Harvard University, Cambridge, Mass.; Russell C. Lowell, Technical High School, Providence, R. I.; Miss Mary C. Richardson, Normal School, Castine, Maine; A. Harry Wheeler, English High School, Worcester, Mass.

ASSOCIATION OF TEACHERS OF MATHEMATICS IN THE MIDDLE STATES AND MARYLAND.

President, William H. Metzler, Syracuse University; *Vice-President*, Daniel D. Feldman, Erasmus Hall High School, Brooklyn; *Secretary*, Eugene R. Smith, Polytechnic Preparatory School, Brooklyn; *Treasurer*, M. Edna Shaw, William Penn High School, Philadelphia; *Members of the Council* (2 years), Paul N. Beck, George Washington University, Washington, D. C.; (3 years), Howard F. Hart, High School, Montclair, N. J.; Isaac J. Schwatt, University of Pennsylvania.

SECTIONS.

PHILADELPHIA: Henry V. Gummere, *Chairman;* Elizabeth B. Albrecht, *Secretary.*

NEW YORK: Daniel D. Feldman, *Chairman;* Lao G. Simons, Secretary.

PITTSBURG: J. M. Berkey, *Chairman;* J. Buell Snyder, *Secretary.*

ROCHESTER: Arthur S. Gale, *Chairman;* Fred L. Lamson, *Secretary.*

SYRACUSE: Eugene P. Sisson, *Chairman;* Daniel Pratt, *Secretary.*

ASSOCIATION OF OHIO TEACHERS OF MATHEMATHICS AND SCIENCE.

President, Miss Stella S. Wilson, Central High School, Columbus, O.; *Vice-President*, Gordon N. Armstrong, Ohio Wesleyan University, Delaware, O.; *Secretary-Treasurer*, Chas. T. Prose, High School, Zanesville, O.

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President, Otis W. Caldwell, University of Chicago; *Secretary* and *Editor*, Fred L. Charles, College of Agriculture, University of Illinois, Urbana.

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President, Charles F. Cox; *Recording Secretary*, Edmund Otis Hovey; *Corresponding Secretary*, Herman Carey Bumpus; *Treasurer*, Emerson McMillin; *Librarian*, Ralph W. Tower; *Editor*, Edmund Otis Hovey.

NORTH DAKOTA ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

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PHYSICAL SCIENCE SECTION OF THE NEBRASKA STATE TEACHERS' ASSOCIATION.

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PHYSICS CLUB OF NEW YORK.
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SCIENCE AND MATHEMATICS SECTION OF THE HIGH SCHOOL DEPARTMENT OF THE PENNSYLVANIA STATE TEACHERS' ASSOCIATION.
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SOUTHERN CALIFORNIA SCIENCE AND MATHEMATICS ASSOCIATION.
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UTAH ACADEMY OF SCIENCES.
President, Dr. W. C. Ebaugh, University of Utah; *First Vice-President,* Dr. E. D. Ball, Utah Experiment Station; *Secretary,* A. O. Garrett, Salt Lake High School; *Treasurer,* Dr. Philena Fletcher Homer, B.Y.U., Provo.

BOOK REVIEWS.

Price List of Chemical and Bacteriological Apparatus and Assayer's Supplies. 1910. Pages 333. E. H. Sargent & Co., 143 Lake St., Chicago.

This is one of the most complete catalogues we have ever seen. It is a complete revision of their former catalogue of chemical apparatus. One of the valuable features is a nine page descriptive list of up-to-date scientific books, with prices. The cuts are all new genuine wood cuts especially made for this edition.

The book is very handsomely and expensively gotten up. Paper and press work are perfect. C. M. T.

Catalogue of Chemical Laboratory Requisites. Sixth edition. 1910. Pp. 720.

A Treatise on Scientific Instruments, Physics. Fifth edition. 1908. Pp. 730. Philip Harris & Co., Ltd., Birmingham, England.

These two volumes are the most extensive and expensively gotten up catalogues we have ever seen. It is printed on coated paper. Nearly every article in the catalogue is illustrated. The cuts are all either half tones or made from genuine wood cuts.

In physics many new, novel and reasonably priced pieces of apparatus are shown. C. M. T.

BOOKS RECEIVED.

Plane Trigonometry and Tables, by Fletcher Durell, Lawrenceville School, N. J. Pages 184+133, 16x24 cm; cloth, \$1.25. Charles E. Merrill Company, New York.

A High School Course in Physics, by Frederick R. Gorton, State Normal College, Ypsilanti, Michigan. Pages XV+480; 14x19 cm.; cloth. D. Appleton & Company, New York and Chicago.

Tillers of the Ground, by Marion I. Newbigin, Editor *Scottish Geographical Magazine*. Pages VIII+224; 12x17 cm.; cloth; 50 cents, net. Macmillan and Company, New York.

Medical Education in the United States and Canada: A Report to the Carnegie Foundation, by Abraham Flexner. Bulletin No. 4. Pages XVII +346; 19x25 cm. The Merrymount Press, Boston.

Elements of Algebra, by Arthur Schultze, New York University. Pages XII+309; 13½x19 cm.; 80 cents, net. Macmillan Company, New York.

What to Do at Recess, by George E. Johnson, Supt. of Playgrounds, Park and Vacation Schools, Pittsburg. 12mo., cloth; pages 33; illustrated; price, 25 cents. Ginn & Company, Boston, Chicago.

Elementary Cabinet Work, by Frank H. Selden, State Normal School, Valley City, N. D. Pages 278; 13x17 cm. Rand, McNally & Co., Chicago.

The Building and Care of the Body, by Columbus N. Millard. Pages XI+235; 13x17 cm.; cloth, 40 cents, net. The Macmillan Company, New York.

The Teaching Botanist, by William F. Ganong, Smith College. Pages XI+439; 14x19 cm.; \$1.25, net. The Macmillan Company, New York.

Fields of Force: A Course of Lectures in Mathematical Physics, by Vilhelm Friman Karen Bjerkner, University of Stockholm, delivered at Columbia University. The Columbia University Press, New York.

Second-Year Mathematics, by George W. Myers and assistants, College of Education, University of Chicago. Pages XIV+282; 14x19 cm.; cloth; postpaid, \$1.63. The University of Chicago Press.

The Soul of a Serf, by J. Breckenridge Ellis. Pages 328; 14x19 cm.; cloth; \$1.00. Laird & Lee, Chicago.

Transactions of the Illinois State Academy of Science. Volume III, 1910; pages 172. Schnepp & Barnes, Springfield.

Proceedings of the Fifteenth Annual Meeting of the North Central Association of Colleges and Secondary Schools. Chicago Meeting. Pages 208. Published by the Association, T. A. Clark, Sec'y, Urbana, Ill.

Essentials of Chemistry, by Rufus P. Williams, Instructor in Chemistry, English High School, Boston. 8vo., cloth; 421 pages; \$1.25. Ginn and Company, Boston, Chicago.

BOOK REVIEWS.

Second-Year Mathematics for Secondary Schools, by George W. Myers, Professor of the Teaching of Mathematics and Astronomy, College of Education of the University of Chicago, and the Instructors in Mathematics in the University High School. Pp. XIV+282. Price, \$1.63. 1910. The University of Chicago Press.

The First-Year Mathematics, by the same authors, which places chief emphasis on algebra, connects closely with the mensuration and general number of the eighth-grade arithmetic, and makes considerable advance in preliminary geometrical work.

The Second-Year Mathematics is a geometry in which there are continual applications of algebra. This use of the algebraic notation and equation to solve geometrical problems, together with the development of algebraic topics not included in the first year's work, means that both algebra and geometry in close combination have a share of the student's attention for two years. To adapt to our needs a method of teaching mathematics developed in other countries by years of careful study ought not to be a very rash experiment.

As one turns over the pages of this book the following features are noticeable: Construction problems to open up the subject; the large number of exercises, constructional, numerical, algebraic, and demonstrable; the use of the principles of congruency; many proofs in outline, or left entirely to the student; "new" proofs; early use of circles; early use of ratio and proportion; the simple treatment of incommensurables and limits; the properties of proportion developed by means of exercises; applications of similar triangles; angle-functions, and their use in solving right triangles; similarity and proportionality in circles; quadratic equations; inequality in triangles and circles brought together in one chapter; new ideas in the treatment of areas of polygons; use of the graph; degree of rigor suited to the ability of high school pupils.

This book seems to be not such a wide departure from traditional methods as does the First-Year Mathematics; and it may find place in schools where the latter book does not seem expedient. It covers the ground of the usual secondary school geometry, and appears to be very teachable. H. E. C.

A Treatise on the Differential Geometry of Curves and Surfaces, by Luther P. Eisenhart, Professor of Mathematics in Princeton University. Pp. 474. $4.50. 1909. Ginn and Company.

This book serves as an introduction to the methods of differential geometry and develops the theory of curves and surfaces to such an extent that the student will be prepared to read the more extensive foreign treatises and journal articles. The method generally used is that of Gauss, by which the properties of a surface are derived from the discussion of two quadratic forms. The kinematical view of the theory, however, has been developed at some length.

The number of problems, about seven hundred, is noticeably large for such a treatise as this, and not only do they furnish direct applications of formulas, but they also constitute extensions of the theory. The book presents a most attractive appearance. It is a pleasure to turn the pages and note the results obtained by graceful type, well-balanced spacing, and carefully drawn diagrams. H. E. C.

Exercises in Geometry, by Grace L. Edgett, Beverly, Mass. Pp. 81. 1909. D. C. Heath and Company.

This little book is a collection of eight hundred and nineteen exercises, in part taken from text-books and in part evolved in the author's class room. They are arranged in sixty-one groups, and are in the nature of an appendix to the Harvard "Syllabus of Propositions in Geometry." About one-third of the exercises are numerical. H. E. C.

The Teaching Botanist, by William F. Ganong, Professor of Botany in Smith College. Second Edition. XI+439 pages. 40 cuts. Price, $1.25, net. The Macmillan Company, New York.

This second edition of a widely known and highly useful handbook for teachers of botany is decidedly improved. It contains more than one and a half times as much matter as the earlier book, and handles the topics

treated with a grasp even more assured than was manifest in the first edition. To the majority of teachers the most novel and interesting portion of the book is that comprised in the "Chapters on Subjects Important in Botanical Education" of Part I. Here are found answers to the questions why botany should be studied, what kind of botany should be studied, how the teacher should be trained, what methods he should use. Botanical laboratories and collections are carefully discussed and a detailed bibliography of botanical works especially useful to teachers is given, after a good account of the classes of botanical works, their scope and value. Not the least useful of the chapters of Part I is that on "Some Common Errors Prejudicial to Good Botanical Teaching."

Part II gives detailed directions for a one-year course in botany, comprising first the study of the structure and functions of plants and then the natural history and classification of the groups of plants. The outline is eminently workable, the outcome of much experience in teaching the subject to somewhat mature beginners. Nothing is recommended on hearsay. The portion of the course which will be found most suggestive by teachers in general is that which relates to plant physiology as a laboratory subject. To the reviewer this seems a most valuable feature of the book, since the tendency was for too long to look askance at plant physiology as over difficult for the beginner in botany. And yet it hardly requires any argument to show that plant study without a considerable infusion of physiology is no better than the study of the human body with the attention mainly given, let us say, to osteology and myology, with some excursions into ethnology.

On the whole the book is one which no instructor in elementary botany can afford to do without. J. Y. B.

A High School Course in Physics, by Frederick R. Gorton, Ph.D., Associate Professor of Physics, Michigan State Normal College. 8vo., 480 pp. D. Appleton & Co. 1910.

In this new text in physics, Professor Gorton has developed an admirable, well-balanced treatment of the subject. It contains twenty-one chapters arranged as follows: eight in mechanics, two in sound, two in heat, three in light, and six in magnetism and electricity. The position of heat is unusual, being placed *between* sound and light; while magnetism appears between static and current electricity.

The preface states: "In the presentation of demonstration experiments the author has described as simple and inexpensive apparatus as he has found to be consistent with satisfactory results." "As an aid to the pupil and to the teacher in conducting rapid drill exercises, a summary of the contents of each chapter is presented at its conclusion." Twenty portraits, with brief biographies of "many of the great men of science," are included "as an important factor in creating an atmosphere of human interest around the subject."

There are 583 problems and exercises arranged in 71 groups. They are direct and practical. "Illustrative solutions of problems and suggestions have been given wherever difficulties have been found to arise." This helpful feature has been carried out more thoroughly than in other recent texts.

The book is well illustrated, containing 411 diagrams and figures. In compiling the subject-matter the author has given careful attention to the various topics recommended by the Committee of Secondary School Teachers to the College Entrance Examination Board.

The text deserves careful consideration. It is comprehensive, simple in style, contains numerous illustrations of the topics and principles presented and from a pedagogical standpoint gives promise of being a very satisfactory text in high school physics. W. E. T.

Tillers of the Ground, by Marion I. Newbrigen of the Edinburg School of Medicine, published by Macmillan and Company, London. pp. 224. Price, 50 cents.

Tillers of the Ground attempts a descriptive statement regarding some important agricultural topics. It is in no sense a laboratory guide or text-book, but contains excellent discussions of topics such as should greatly broaden the horizon of those who are interested in applied science. Some of the chapter headings suggest the scope of the book: Primitive Tillers of the Ground, Reclaiming the Desert, The Spreading of Food-Plants, Introducing Dates into North America, Improving Cultivated Plants, The Struggle with Disease, Plant Food and Utilization of the Soil, The Gains that Knowledge has Brought, etc.

The discussion of The Utilization of the Soil well illustrates the author's treatment of topics. After a brief statement of the necessity of a study of soil in its relation to agricultural plants, the author limits himself to the problem of nitrogen supply in agricultural soils. He reviews Liebig's experiments and his conclusions that since in burning plants the ammonia and carbon dioxide pass into the air, living plants, therefore, can again secure their carbon dioxide and nitrogen compounds from the air. According to Liebig, mineral salts exclusive of nitrogen compounds must be supplied to the soil, and these Liebig claimed could best be supplied by means of mineral fertilizers rather than manure. Liebig was wrong regarding nitrogen, but did make a great contribution in teaching agriculturists the use of mineral fertilizers.

Boussingault then in a long series of experiments tried to find if plants growing in water and air could take nitrogen from the air. He concluded that they cannot. This work was followed by Lawes and Gilbert (1860), who worked on the famous farms at Rothamsted, England, and who also concluded that plants cannot take nitrogen from the air. Their experiments with the pea family, resulting in the conclusion that no nitrogen is taken from the air at the same time, gave interesting results, since under the conditions of the experiments (sterile soil) their plants did not grow well.

In 1876 Berthelot in France pointed out that soil bacteria may secure nitrogen from the air, though he merely suggested the possibility of a relation of this fact to agriculture. In 1886 the German scientist, Hellriegel, reported his experiments showing conclusively that soil bacteria and the tubercles on roots of members of the pea family are factors in securing the nitrogen supply from the air.

Although this chapter does not include recent important results in this country relative to agricultural soils, it does present an interesting and authentic account of the soil-nitrogen problem. Other chapters are similarly interesting and important. O. W. C.

Geometry for Beginners, by C. Godfrey, M.A., Head Master of the Royal Naval College, Osborne, and A. W. Siddons, M.A., Assistant Master at Harrow School. Pp. 79. Price, 1 s. 1910. Cambridge, at the University Press.

This book follows quite closely the recommendations of the Board of Education Circular on the Teaching of Geometry (and Graphic Algebra) in Secondary Schools, 1909. The main conclusions of the Board are well worth recording here: "The teaching of elementary geometry should be in three stages.

"*First Stage.* Introductory practical work concerned with the fundamental concepts, and not primarily designed to give facility in using instruments.

"*Second Stage.* Experimental work leading up to the discovery of the fundamental facts of geometry; including angles at a point, parallels, angles of a triangle and polygon, congruent triangles.

"*Third Stage.* The rigid deductive development of the subsequent propositions on lines that are now familiar.

"It is recommended that the fundamental facts discovered in the Second Stage shall not be treated as theorems to be proved deductively. In support of this view it is argued (1) that the deductive proofs of these propositions present more difficulties and are less persuasive than the proofs of propositions that follow; (2) that difficulties of sequence are for the most part confined to these propositions; (3) that, in the experience of the Board, subsequent work is better in those schools where these fundamental propositions are dealt with more rapidly. 'These fundamental propositions are those on which all the subsequent deduction depends, and the essential thing in regard to them is not to analyze them and reduce them to the minimum number of axioms, or, rather, postulates (which is Euclid's method), but to present them in such a way that their truth is as obvious and real to the pupils as the difference between white and black, or between his right hand and his left. Any process which interferes with this directness of vision and apprehension is vicious, whatever claim it may have to logical value, and avenges itself in gross mistakes in subsequent work, due to haziness or lack of grasp of the fundamental facts which have been so laboriously "proved"!' "

Teachers of geometry will find many valuable suggestions in this little book. It contains 470 exercises, and there is a large number of drawings and figures. This method of approach to formal demonstrative geometry is proving its value wherever it is used, even though it is being adopted rather slowly in this country. H. E. C.

Plane Trigonometry, by Fletcher Durell, Ph.D., Head of the Department of Mathematics, The Lawrenceville School, Lawrenceville, N. J. Pp. 184 +133 pages of tables. Price, $1.25. 1910. Chas. E. Merrill Co., New York.

The new features of this book are a chapter of twelve pages on the history of trigonometry, four-place and five-place tables of logarithms, with appropriate examples for each table, and the arrangement of the logarithmic work in the solution of triangles in the form of tabulation used in the designing room in the United States Navy Department.

The author states that the principal object in writing the book has been to bring out the fundamental utilities which underlie and grow out of the principles presented. The fundamental source of new power in trigonometry is frequently emphasized, and each process is taken up for the sake of economy or new power which it gives.

There is a large number of new problems and applications, and full lists of the usual identities, transformations, and equations. The principles are presented clearly; and it seems as if the student would obtain a thorough understanding of the subject. The publisher has done his part of the work well, and in all respects it is an attractive book. H. E. C.

First Course in Algebra, by Herbert E. Hawkes, Professor of Mathematics, Columbia University, formerly Assistant Professor of Mathematics at Yale University, and W. A. Luby and F. C. Touton, Instructors in Mathematics, Central High School, Kansas City, Mo. Pp. 334. Price, $1.00. 1910. Ginn & Co.

It has been the aim of the authors to make an algebra suited to the needs and abilities of high school boys and girls by a careful selection and presentation of traditional material and methods, with a judicious admixture of the newer ideas in the field of algebra. It may safely be called a sensible text-book, and may represent the first stage in the development of greater efficiency in algebra teaching.

There is an abundant supply of problems, and they are of excellent types. The large number of problems based on geometrical and physical ideas furnish to some extent the desirable correlation with physics and geometry. It would seem as if the graph might have been introduced earlier and used to good advantage within the limits of the conservatism that characterizes the book.

The historical and biographical notes are given with sufficient fullness to give the pupils some idea of the way in which algebra has developed. The full page portraits of the men who have contributed largely to the development of elementary algebra is a new feature. H. E. C.

Man in Many Lands: An Introduction to the Study of Geographic Control, by L. W. Lyde, University College, London. 184 pages. Illustrated. 65 cents, net. Macmillan Company, New York.

An interesting little book which the author wrote from a mass of information in the form of questions which he gathered while acting as examiner in geography for various examining bodies. He has endeavored to answer these questions by putting into print a consecutive series of very readable answers. It is a book that anyone may read with interest and profit. The twenty-four illustrations are done in color in harmony with the scenes from which they were taken. There are eleven chapters, in which something of importance is said concerning practically every country on the earth. It is an epitomized history of the globe in tabloid form. The index is incomplete, as the book is primarily for school use and not for reference. C. H. S.

What to Do at Recess, by George E. Johnson, Superintendent of Playgrounds, Park and Vacation Schools, Pittsburg. 12mo., cloth; pages, 33. Price, 25 cents. Ginn & Company, Boston, Chicago.

In order that a child get the most out of his school life, it is just as necessary that he be taught how and what to play as it is to be drilled in those things which are taught from books. The author of this fine little work has put into condensed form many helpful suggestions as to how to manage and interest the boy and girl when they are not actively engaged with their books. In fact, it more than frequently happens that the boy and girl coming fresh from some game have a better relish for the things they are to study in books. The up-to-date teacher of primary and intermediate grades must not only know how to impart book knowledge but must be able to amuse and entertain the children at play; by so doing their influence for good on the youngsters will be greatly enhanced. Teachers of all grades below the high school should purchase and make use of this little book. C. H. S.

The Building and Care of the Body, by C. N. Millard, Supervisor of Grammar Grades, Buffalo, N. Y., Public Schools. Pages XI+235; illustrated; 13x19 cm.; cloth; 40 cents, net. The Macmillan Company, New York.

A book which is clear, readable, concise, and to the point. It is primarily for use in the grades below the high school, contains and treats of those subjects which every boy and girl should know about. The gist of the book is teaching the young pupil that the development of a strong, healthy body should be the chief aim of our schools. That unwise habits of eating, uncleanliness, and vile habits with certain organs of the body are in many, many cases the cause of the undermining of one's health. That, on the other hand, the proper care of the body as to breathing, exercise, rest, proper food, and freedom from evil habits are very important factors in securing and preserving the health. The author does not say thou shalt or thou

shalt not do this or that, but, on the other hand, in a splendid manner tries to convince the pupil that he will be more successful in work or play, better looking, more useful and better all around if he carries out the principles mentioned in the book. Strong emphasis is made to impress the pupil with the inestimable value to the body of the eyes, ears and teeth, and states clearly the manner in which these organs should be cared for. The illustrations are many and well selected. There are thirty-nine chapters, each having near the close a paragraph on "points for special study." Each chapter closes with a list of questions to be answered, which are suggested by the topics discussed in it. The important paragraphs begin with heavy bold-face type, the body of the book being printed in large, clear type. There is a glossary of four pages, as well as a complete index. It is one of the best books on the subject ever published, and doubtless will have a large sale.

C. H. S.

Elementary Cabinet Work, by Frank H. Selden, State Normal School, Valley City, N. D. Pages 278; 13x17 cm. Rand, McNally & Co., Chicago.

To one interested in manual training, either as a layman or teacher, this book will be an inspiration. The author is a past master at instruction in the art of constructing anything from wood in the cabinet or furniture line. It is illustrated with 288 drawings and half-tones, many of the latter being taken from finished work and from pupils in actual work when a principle is to be illustrated. The drawings are all dimensional. The purpose of the book is to make clear by means of definite directions the fundamental principles of furniture making. A good working knowledge of the use of tools in cabinet work is absolutely necessary before one will be able to carry out the principles discussed in the work. The book is divided into three parts. Part I treats of the general directions for cabinet work, telling how to apply the principles of wood working with which the person must already be familiar. Part II describes and tells about several examples of furniture construction which have been actually worked out and which lie within the ability of the person to make. Part III describes several special tools used in this kind of construction, as well as giving descriptions of different ways in which cabinet work may be finished. There is a complete index of four pages. The type is large and clear, making the book easily read. The main paragraphs begin with bold-face type. Mechanically, the book is well made and will stand hard usage. All persons interested in constructing cabinet work should own a copy.

C. H. S.

The Care of Trees in Lawn, Street and Park, by Bernhard E. Fernow, University of Toronto. X+392 pages. Illustrated. Henry Holt and Company, New York.

People interested in the development, growth and cultivation of trees and shrubs in country, city and park will welcome to their libraries this splendid volume. No one is better qualified to write a book of this character than this author, who is the foremost forester of North America. It is intended primarily for amateur planters of trees and is written in such a comprehensive manner that he cannot help but secure much valuable information which will enable him to better care for his plants; at the same time broadening his knowledge of tree culture so that he will have a more profound respect for those who are experts in caring for trees, going to them for advice when coming against questions and conditions which he is unable to solve.

Chapter II relates to structure and life of trees, discusses the growth and form development, physiological and ecological points, as well as the

recuperative capacity. Chapter III speaks of diseases and death of trees, while Chapter IV is devoted to the diagnosing of diseases from different points of view. Chapter V treats of the control of physiological diseases and treatment of mechanical injuries. In Chapter VI the control of parasites is thoroughly discussed. Chapter VII is devoted to the care in planting, while the last two chapters deal with esthetic forestry and choice of plant material, respectively. Two pages are devoted to a list of texts on subjects kindred to this. A very complete index of sixteen pages is appended. The subjects for illustration by cuts and drawings show judgment in their selection, all being well executed. The body of the book is printed in clear ten-point type. The mechanical work is of the highest quality. C. H. S.

The Evolution of Forces, by Dr. Gustave LeBon, Member de L'Académie Royale de Belgique. XV+388 pages, with 42 figures; 13x19 cm. D. Appleton and Company, New York.

This is a magnificent volume, in which the author still further describes his theories advanced in L'Evolution de la Matière. It is a book which ought to be read and studied by everyone interested in physics, as by so doing he is brought in touch with those theories which are being investigated by the authorities in this subject in Europe.

The book consists of two parts. The first, of 99 pages, is headed, "The New Principles;" the second, of 289 pages, "The Problems of Physics." Part I is divided into four books and Part II into five books. The books are still further subdivided into chapters. There is no better way to get the contents of the work before the mind of the reader of this review than to give the titles of the chapters. They are as follows: Present Anarchy of Science; The New Doctrine; Time, Space, Matter, and Force; Great Constants of the Universe; Resistance and Movement; Building Up of Forces and the Mechanical Explanations of the Universe; Monistic Conception of Forces and the Theory of the Conservation of Energy; Energetical Explanation of Phenomena; Degradation of Energy; Individualization of Forces and the Supposed Transformations of Energy; Changes of Equilibria of Matter and the Ether Origin of Forces; Origin of Matter and Universal Forces; Vanishing of Energy and End of Our Universe; Dematerialization of Matter and the Problems of Electricity; Genesis of Current Ideas on Relations of Electricity and Matter; Transformations of Matter into Electricity; Problems of Magnetism, Magnetic Induction, and Lines of Force; Electric Waves; Transparency of Matter to Electrical Waves; Different Forms of Electricity and Their Origin; Problems of Heat; Transformation of Material Movements into Ethereal Vibrations and Radiant Heat; Transformation of Matter into Light; Dematerialization of Matter by Light; Phosphorescence Produced by Light, Heat and from Other Causes; Causes of Phosphorescence; Invisible Phosphorescence; Infra-red Rays and Photography through Opaque Bodies; Part Played by the Various Luminous Radiations in Vital Phenomena; Antagonistic Properties of Some Regions of the Spectrum; Universal Gravitation and Hidden Forces; Molecular and Intra-atomic Forces; Forces Manifested by Living Beings.

The book possesses the highest degree of merit, and how well the French appreciate it is shown by the fact that eight editions of 1,000 copies each were exhausted before it appeared in English.

The book on Black Light, or the invisible radiations given off by certain phosphorescent bodies, is timely and interesting. It is well for the science that such men as LeBon are investigating in these fields, as all there is to be known concerning the phenomena connected with radiations has not yet been discovered.

There is a complete index of subjects, as well as one of names. It is a book which should have a large sale. C. H. S.